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BIRD'S EYE VIEW OF UNAKA SPRINGS, TENN., ON THE NEW CAROLINA, CLINCHFIELD & OHIO RAILWAY.

THE COSTLIEST RAILROAD IN AMERICA.—[See page 71.]

CARBON DIOXIDE AND CHIMNEY LOSSES.*

THEIR REAL RELATION.

BY JAMES E. STEELY.

THERE has been considerable work done recently relating to the economic combustion of coal, and it is possible that the average engineer is led to believe that to secure a high economy it is necessary to get a high percentage of CO_2 in the flue gas. Under a very few conditions a high CO_2 and a low flue-gas temperature will indicate a high economy or at least a low chimney loss, but it is not to be supposed that these factors always indicate such a condition. It is an easy thing to get a continuous record of both the temperature and the percentage of CO_2 in the flue gas, as continuous recording machines are on the market, some of which will give as accurate analysis as could be obtained with an Orsat apparatus. However, the fact seems to have been overlooked that while the percentage of CO_2 is a very desirable thing to know, it cannot be used with certainty in calculating chimney losses, and in almost all cases it affords only a crude approximation, while in many it is 20 or 30 per cent off the true loss.

PROXIMATE AND ULTIMATE ANALYSES.

In spite of modern educational advantages the ordinary engineer has not the chemical foundation so helpful in the managing of a boiler house, and a little time devoted to the explanation of some boiler-house chemistry will no doubt be well spent. When a sample of coal is sent to a chemist for analysis, two reports usually come back with it as follows:

Proximate Analysis.	
Moisture	3.74
Volatile combustible	41.96
Fixed carbon	42.89
Ash	11.41

Ultimate. Analysis.	
Hydrogen (H)	4.61
Carbon (C)	61.80
Oxygen (O)	10.90
Nitrogen (N)	0.97
Sulphur (S)	5.20
Ash	16.52

The proximate analysis is a sort of an arbitrary one. The moisture is the moisture or water in the coal. The volatile combustible is those gases which distill off when the coal is heated without access to air. This comprises all the hydrogen, some carbon and part of the sulphur.

When the coal is fired the volatile matter distills off first and burns with a long flame. If insufficient air is present or if the flame hits a cold surface such as a boiler tube, smoke is formed. Thus it will be seen that continuous firing, as with automatic stokers, would keep a little of these volatile gases coming off all the time, while hand firing would distill off a large quantity of combustible gases at once, which would only partly burn, thus causing loss and smoke. The remaining substance is nearly pure carbon mixed with the ash. The combustible in the ash and refuse from the boiler is also carbon. The hydrogen, nitrogen, part of the sulphur and oxygen have been burnt or distilled off.

CHEMICAL ELEMENTS IN COAL.

In the ultimate analysis there are a series of chemical elements. Hydrogen is a combustible gas, but it exists in coal as a complex hydrocarbon. When the coal is heated it distills off as CH_4 or marsh gas. In burning, hydrogen combines with one-half of its volume or eight times its weight of oxygen, and as oxygen exists in the air to the extent of about 21 per cent by volume or 23 per cent by weight, the amount of air necessary for its combustion can be calculated.

Carbon is an amorphous solid which can burn to CO using 16 weights of oxygen to 12 of carbon, or it can burn to CO_2 using 32 weights of oxygen to 12 of carbon. The former is a combustible gas and is the principal constituent of producer gas, while CO_2 is the final product when CO burns as well as when the carbon burns completely.

A hydrocarbon is a compound consisting of hydrogen and carbon, which may be gas, a liquid or a solid. When a hydrocarbon burns with insufficient air, the hydrogen burns off and deposits the carbon as soot. This also happens if the flame is cooled.

Oxygen is a non-combustible gas, but it is the best known supporter of combustion. It exists in the coal in combination with the carbon and hydrogen, but exists in the air in a free state in the proportions previously given.

Nitrogen is non-combustible and does not support combustion. It is the most inert of the elements. It exists in the form of a gas and the air contains 79 per cent of it by volume and 77 per cent by weight. In the coal it is found in combination with the carbon and hydrogen.

Sulphur exists in coal as sulphide of iron or pyrites and also as sulphate of lime. The sulphur as sulphide will partly burn off. When sulphur burns it combines with an equal amount by weight of oxygen, forming SO_2. This is an acid when mixed with steam or water and will rapidly corrode iron and many metals. The ash in coal is the non-combustible mineral matter.

Mention might be made of chemical symbols and statement of chemical reactions. For abbreviation chemists use a kind of shorthand for representing elements. Thus the letter H represents the element hydrogen; C, carbon; S, sulphur; N, nitrogen; O, oxygen; CH_4, a hydrocarbon, etc. Now, when carbon burns as previously stated, it unites with oxygen to form CO and CO_2. This would be represented as follows:

	$C + O = CO$
Parts by weight	$12 + 16 = 28$
Parts by volume	$\frac{1}{2}$ 1

or

	$C + O_2 = CO_2$
Parts by weight	$12 + 32 = 44$
Parts by volume	1 1

The weights represent the combining weights of the elements and the volumes represent the volumes used or formed, as found by applying the well-known law of Avogadro.

THEORETICAL COMBUSTION.

Combustion proper may now be treated from a theoretical standpoint, using the figures 21 per cent by volume of oxygen and 79 per cent of nitrogen as the composition of air.* If pure carbon were burned with the correct amount of air, a mixture of nitrogen and CO_2 would be obtained, which would analyze nitrogen 79 per cent and CO_2 21 per cent by volume, as oxygen in combining with carbon forms its own volume of CO_2. This is impossible under furnace conditions, but if there were nothing else in the coal and it were burnt, the percentage of CO_2 and O would always add up to 21 per cent by volume, and the per cent of CO_2 could be used accurately to determine chimney losses. However, there are a large number of reactions which take place, all of which remove the CO_2 farther and farther from the true indication.

Taking some of these reactions up separately, the effect of each can be seen. When hydrogen burns, it forms water, or steam if the temperature is above 212 deg. F. If pure hydrogen were to be burned with the air in the exact amount, the resulting gas, when cooled, would be 100 per cent nitrogen, as the hydrogen would combine with all the oxygen and form water when the sample cooled. The same thing happens when the hydrogen in coal burns. When the flue-gas sample is taken, the steam condenses and the analyzed sample shows a slightly higher percentage of CO_2 than is really in the flue. Taking a coal with 75 per cent carbon and 5 per cent hydrogen, the flue gas, using theoretical amounts of air, would analyze as follows:

Steam by volume	0.69 per cent
CO_2 by volume	20.59 per cent
Nitrogen by volume	78.72 per cent

The sample which the chemist would get would analyze:

CO_2	20.73 per cent
N	79.27 per cent

on account of the condensation of the steam. This error, however slight, is actual, and the higher the percentage of hydrogen in the coal or fuel, the greater it is. Any steam moisture in coal or water put in the fire will also serve to dilute the chimney gas, but will not interfere with the calculation of the heat losses except in so far as it uses up heat in raising the moisture to the temperature of the flue gases. It will not cause error in the analysis of the gases actually caused by the burning of the coal. Even if it is decomposed by the fire, it will liberate the same heat as was used in decomposing it and also return to exactly the same amount of steam by weight.

The sulphur in the coal burns to SO_2, and this is easily absorbed by the potash solution which is used for absorbing the CO_2, thus tending to indicate a higher CO_2 than the true amount. CO also influences the result. Supposing that a flue gas containing 10 per cent of CO_2 contains 0.2 per cent CO. The analysis of the CO_2 would indicate the following:

CO_2	10 per cent
O	11 per cent
N	79 per cent

while the true analysis would be

CO_2	10.00 per cent
O	10.88 per cent
CO	0.20 per cent
N	78.92 per cent

These errors are ordinarily slight, but in extreme cases may be appreciable. They actually exist, no matter how carefully the CO_2 is determined.

ACTUAL ANALYSES SHOW CO_2 ERRATIC.

Taking some actual results and working out the losses, the percentage of CO_2 may be shown to be very erratic. The following two analyses were made by the U. S. Geological Survey at the fuel-testing plant in St. Louis. The coal used was New Mexico No. 1, and both samples were taken during the same test at different times:

Sample 1.		Sample 2.	
CO_2	8.7	CO_2	10.1
O	10.4	O	8.6
CO	0.0	CO	2.1
N	80.9	N	79.2

From the percentage of CO_2 it would be reasoned that Sample 2 was very much better, i. e., the chimney loss much less. The coal analyzed as follows:

	Combustible.	Coal.
Carbon	78.50	70.77
Hydrogen	5.51	4.97
Oxygen	14.01	12.63
Nitrogen	1.28	1.15
Sulphur	0.70	0.63
Ash	....	9.85
	100.00	100.00

The ash and refuse analyzed: Carbon, 42.98, and earthy matter, 57.02, or 7.42 per cent of the original combustible. Correcting the combustible in the coal for this, the theoretical analysis of the combustible as burnt is obtained as follows:

Carbon	76.96 per cent
Hydrogen	6.04 per cent
Oxygen	15.33 per cent
Nitrogen	1.29 per cent
Sulphur	0.38 per cent

Supposing one-half the sulphur remains in the ash. Now, to burn one pound of this would require the following quantities of air:

0.7696 lb. carbon to CO_2	8.9196 lb. air
0.0604 lb. hydrogen to H_2O	2.1007 lb. air
0.0038 lb. sulphur to SO_2	0.0164 lb. air
Theoretical amount of air	11.0367
Correcting for oxygen in coal	0.6665
Theoretical amount of air	10.3702

This combustion would produce 11.3702 pounds of flue gas of the composition by volume as follows:

	By Volume.	By Weight.
CO_2	16.88	24.80
CO	....	....
O	....	....
SO_2	0.13	0.28
Steam	7.96	4.78
Nitrogen	75.03	70.14
	100.00	100.00

On a dry-gas basis it would analyze:

CO_2	18.44
SO_2	0.14
N	81.42
	100.00

Since the SO_2 would be estimated as CO_2, add the SO_2 and CO_2, and call it CO_2. This would give:

CO_2	18.58
N	81.42
	100.00

It would be well to compare this with the original analysis and thereby note how the errors due to hydrogen and sulphur affect the CO_2 percentage. But in the analysis given the percentage of CO_2 was only 8.7.

*Power and the Engineer.

*To be more exact it is 20.7 and 79.3.

Calculating to this basis, the theoretical analysis of the gas is:

CO_2	8.7
O	11.0
CO	....
N	80.3
	100.00

This is almost identical with the analysis given.

Taking the other sample, or No. 2, 17.48 per cent of the total carbon burns to CO. Thus we would have:

0.6371 lb. carbon to CO_2	7.3839 lb. air
0.1325 lb. carbon to CO	0.7685 lb. air
0.0604 lb. hydrogen to H_2O	2.1007 lb. air
0.0038 lb. sulphur to SO_2	0.0164 lb. air
	10.2695
Correcting for oxygen in coal	0.6665
Theoretical amount of air	9.6030

This would produce 10.603 pounds of flue gas of the composition:

	By Volume.	By Weight.
CO_2	14.22	21.23
CO	3.09	2.93
N	74.09	70.37
SO_2	0.15	0.31
H_2O	8.45	5.16
	100.00	100.00

On a dry basis this would be by volume:

CO_2	15.54
CO	3.37
SO_2	0.16
N	80.93
	100.00

On adding the CO_2 and SO_2 the percentages by volume would be:

CO_2	15.70
CO	3.37
N	80.93
	100.00

Figuring this down to the 10.1 per cent CO_2 basis would give:

CO_2	10.1
CO	2.2
O	8.1
N	79.6

This also compares favorably with the original. In figuring the gas to a lower CO_2 percentage, the calculated amount of air is added, thus introducing some oxygen. The above will show how the errors compensate one another, so that the actual error might not be great in some cases. However, if the above gas still had its steam in it, the percentage of CO_2 would be 9.6 per cent by volume instead of 10.1 per cent.

HEAT LOSSES.

The heat losses, which are more important, will now be given attention. Taking Sample 2, the analysis of the diluted gases by weight would be something like the following:

CO_2	13.71
CO	1.90
SO_2	0.19
H_2O	3.33
N	45.43
Air	35.44
	100.00

One pound of fuel would produce 16.31 pounds of flue gas. To make one pound of this mixture would require 0.938 pound of air. Supposing the air to be 72 deg. F. and the flue gases to be 600 deg. F., the heat balance would be somewhat like the following:

	B.t.u.
Total heat in 0.1371 lb. CO_2 at 600° F.	16.89
Total heat in 0.0190 lb. CO at 600° F.	2.66
Total heat in 0.0019 lb. SO_2 at 600° F.	0.16
Total heat in 0.0333 lb. steam at 600° F.	44.60
Total heat in 0.4543 lb. N at 600° F.	62.73
Total heat in 0.3545 lb. air at 600° F.	47.80
Total heat above 32° F. in 1 lb. flue gas at 600° F.	174.84
Total heat above 32° F. in 0.938 lb. air at 72° F.	8.91
Loss due to hot flue gas	165.93
Loss due to unburnt CO	83.50
Total heat lost in 1 lb. flue gas	249.43

Calculating the heating value of the combustible from the theoretical analysis, gives 13,615.55 B. t. u. per pound, and as 1 pound makes 16.31 pounds of flue gas, the heating value of the amount necessary to make one pound of flue gas would be:

$$\frac{13{,}615.55}{16.31} = 834.8 \text{ B. t. u.}$$

As 249.43 B. t. u. are lost in the chimney, the loss in fuel would be 29.88 per cent.

Taking up Sample 1 and treating it in a similar manner, the diluted flue gas will analyze by weight:

CO_2	11.63
SO_2	0.13
H_2O	2.24
N	32.79
Air	53.21
	100.00

This mixture requires 0.959 pound air to make one pound. Taking the temperatures as in Sample 2, the following heat balance is obtained:

	B.t.u.
Total heat in 0.1163 lb. CO_2 at 600° F.	14.28
Total heat in 0.0013 lb. SO_2 at 600° F.	0.11
Total heat in 0.0224 lb. steam at 600° F.	30.01
Total heat in 0.3279 lb. N at 600° F.	45.38
Total heat in 0.5321 lb. air at 600° F.	71.78
Total heat above 32° F. in flue gas	161.56
Total heat above 32° F. in 0.959 lb. air	9.10
Total heat lost	152.46

One pound of fuel makes 24.26 pounds of this gas, therefore the heating value of the fuel required to make one pound of flue gas is 561.2 B. t. u., and the loss in fuel in this case would be 27 per cent.

The reader has no doubt noticed that in these two cases the highest economy was obtained with the lowest CO_2. If the sample with the highest CO_2 had been free from CO, the loss would have been but 18.96 per cent, or over 10 per cent of the total fuel. This is an error of over 50 per cent in what would be calculated from the CO_2 percentage alone. The fireman is urged

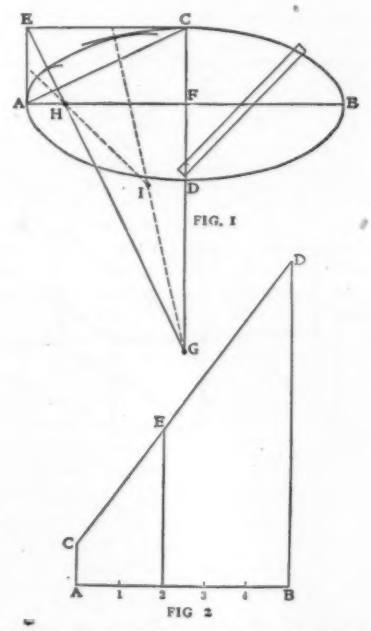


FIG. 1

FIG 2

DRAWING AN ELLIPSE WITH COMPASSES.

to get a high CO_2. He gets it, but how much CO does he get along with it? His CO_2 determinations tell him he is saving 10 to 15 per cent or more fuel, but possibly the complete analysis might show that he is merely adding to his losses.

Some types of boiler setting cause more loss and lower CO_2 than others. Thus, if the gases are cooled below the temperature at which combustion takes place before they are completely burned, there will be low CO_2 and some CO loss. At the St. Louis fuel-testing plant samples were taken of the gas over the fire and the gas at the rear of the combustion chamber. The analyses in test No. 362 are given as follows:

	Over Fire.	Rear of Combustion Chamber.
CO_2	6.1	11.4
O	...	7.7
CO	17.9	...
H_2	7.8	...
CH_4	3.6	...
Other hydrocarbons	0.2	...

Thus it will be seen that it is possible for a low CO_2 to be the cause of the boiler setting, and that it would be impossible for the fireman to raise it, not to say anything of the enormous loss of fuel attending.

Some may say that the examples given above are extremes. It may be true, but how is it known whether a certain case is an extreme or not? If the percentage of CO_2 is known and the percentage of CO is known, then the remainder of the analysis can be calculated from the analysis of the coal as above.

If this article is followed carefully it will be seen how unreliable is the percentage of CO_2, when used alone, to calculate chimney losses. When a boiler test is made and the heat balance made up, the loss due to hydrogen in the coal and to the CO formed is always taken into consideration as well as moisture in the coal and the steam admitted into the fire. While these last two items add to the chimney losses, the only loss is the heat required to raise them up to the temperature of the flue gases.

DRAWING AN ELLIPSE WITH COMPASSES.

IN Kent's Handbook, geometrical problem No. 45, third method, a process is given for drawing an ellipse with compasses, using eight centers. The method, as regards the radii for the side and end curves, is simple, and gives radii which, for ordinary ellipses, are approximately correct. The method of getting the radius for the curve to connect these two is, however, not only complicated, but it gives a radius which is much too short for narrow ellipses.

Here is a method for getting this third radius which is not only much simpler, but which gives a radius that works well on either wide or narrow ellipses. The whole process of drawing is as follows, reference being had to the accompanying illustrations.

Lay out the long diameter *A B* and the short diameter *CD*, Fig. 1, crossing each other centrally at *F*. Construct the parallelogram *A E C F*, and draw the diagonal *A C*. From *E* draw a line at right angles to *A C*, crossing the long diameter at *H* and meeting the short diameter, extended, if necessary, at *G; H* is the center, and *A H* the radius for forming the end of the ellipse; *G* is the center, and *C G* is the radius for forming the side. To this point the process is the same as that given by Kent.

To get the third radius lay off a base line *A B*, Fig. 2, of any convenient length, and divide it into five equal parts by the points 1, 2, 3, and 4. At one end of this line erect the perpendicular *A C*, equal to the radius *A H*, and at the other end erect the perpendicular *B D*, equal to the radius *C G*. Connect the upper ends of these perpendiculars by the line *C D*. From point 2 erect the perpendicular 2 *E*. The length 2 *E* will be the desired third radius. With the compasses set to this radius find, by trial, a center *I*, Fig. 1, from which a curve can be struck which will be just tangent to the curves struck from the centers *H* and *G*. Lines drawn from *I* through *H* and from *G* through *I* will determine the meeting points of the different curves. From other centers similarly located the remainder of the ellipse is formed.

For narrow ellipses the radius *A H* with which the ends are formed should be lengthened somewhat as follows: When the breadth of the ellipse is one-half of its length, lengthen *A H* one-eighth; if the breadth of the ellipse is one-third of its length, make *A H* one-quarter longer; if the breadth is one-quarter of the length, make *A H* one-half longer.

With this modification of the end radius the method gives curves which blend well together so as to satisfy the eye, and gives an outline which, when tested by the trammel method of locating points in the outline of an ellipse, as shown at the right, Fig. 1, is found to conform quite closely to the correct figure.

It may be objected to this method that the center *I* has to be found by trial. But the method given by Kent, while pretending to give the center, does not exactly do so, it being necessary to relocate it by trial. —American Machinist.

In the Proceedings of the Royal Society, J. R. Milne describes a camera designed to take a series of photographs of the scale and vernier of a polarimeter or other instrument, which, on subsequent examination, will show the relative position of the scale and vernier at the time of each exposure. The camera is focused on the scale and vernier, which must be made so that the scale moves, the vernier remaining stationary, and the scale is illuminated in any convenient manner. A simple mechanism is used to make the exposure and to cause the plate to move on to a new position after the exposure is made. In this way 60 photographs, in rows of 10 each, can be obtained on a 5 x 4 inch plate. In order to identify individual photographs, or to indicate the commencement of a new series of records, a means is provided whereby a single or a double wedge-shaped mark can be produced on the photographs, and, to save counting, a bell rings at each tenth exposure. The advantages claimed for this method of making photographic records of the readings of an instrument are: (1) The saving of labor and strain to the eye of the observer, which is left in a better condition for its principal work. (2) The elimination of the possibility of errors of reading on the part of the observer. (3) The great saving of time which is effected. (4) The elimination of all personal bias due to a knowledge of the results that are being obtained. (5) The securing of a permanent record of the readings.

IS A SENSE OF SPACE ACQUIRED?

OUR PERCEPTION AND ESTIMATION OF AREAS AND DISTANCES.

BY P. ALTPETER.

THE actions and assertions of persons who were blind at birth and have subsequently acquired the power of vision through surgical operations prove that our perceptions of distance, area, and solidity, and our ability to distinguish between right and left, up and down, before and behind, are not born in us, but are

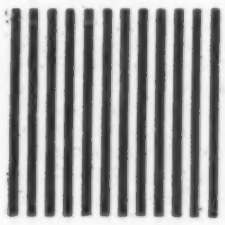


FIG. 1.

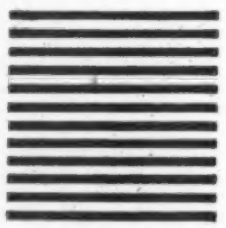


FIG. 2.

acquired by long practice and experience. A person blind from birth, who has learned to distinguish triangles, squares, circles, and objects of other forms by feeling, is not able, immediately after the acquisition of sight, to distinguish these familiar objects by sight alone, but is still compelled to rely upon feeling. In the beginning all objects appear to him as shapeless, tremulous spots of various colors situated close to the eye, and only gradually and by exercise does he learn to recognize their true places, forms, and dimensions. Young infants with normal sight evidently experience a similar course of training, as their actions indicate.

The fact that a chick, immediately after its escape from the shell, is able to run about and pick up food might seem to prove that the faculties of orientation and locomotion may, in some animals, be innate and hereditary, but this inference is unwarranted. The

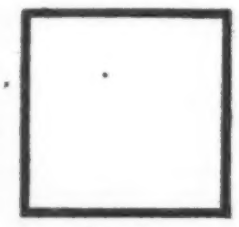


FIG. 3.

newly-hatched chick, if observed very carefully, is seen to move in an uncertain manner, to run against obstacles and often to miss the grain at which it aims. Even the chick, therefore, acquires its spatial perceptions by practice, although it acquires them much more rapidly than human beings acquire theirs.

Let us now examine the method and the organs which are employed in this process.

If the eyes are closed, it is still easy to determine which of two sticks or strings is the longer by drawing the objects between the fingers successively and with about the same velocity. The comparative lengths of the objects are inferred from the times required for the fingers to pass from one end to the other, in each case. Similarly, all distances appear longer in proportion to the times occupied in traversing them. This law may lead to erroneous judgments,

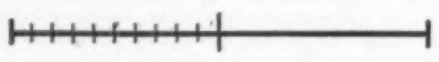


FIG. 4.

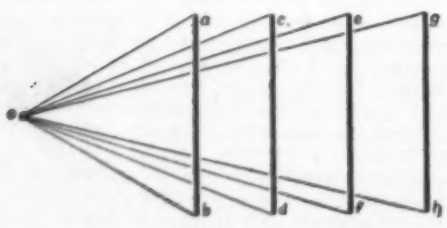


FIG. 5.

for the apparent length of a railway journey depends on the speed of the train, and distances about town are miraculously shortened by the installation of a trolley line. The depth of a well or a pit may be estimated from the time occupied by a stone in falling from the top to the bottom and the distance of a thunder cloud from the interval elapsed between the flash of lightning and the peal of thunder. All of the estimations of length or distance enumerated above are based on estimations of time.

In the same way a person blind from birth obtains, by feeling, a notion of the height of a chair, the length and breadth of a table, the length and thickness of a pencil, etc. Here, evidently, the organs employed are the skin, the muscles, and the sensory nerves.

In estimating a distance by sight, likewise, the controlling factor is the time occupied by the eye in run-

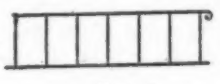


FIG. 6.

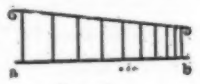


FIG. 7.

ning over the distance, and the muscular sense is again called into play. Thus the breadth of a vertically ruled square (Fig. 1) appears greater than its height, because the eye, in sweeping over it horizontally, is momentarily arrested and consequently delayed by each line, but is not thus delayed in traversing the figure vertically. For the same reason the height of a horizontally ruled square (Fig. 2) appears to exceed its breadth. Hence the apparent height of a woman is increased by a gown having horizontal stripes or flounces and diminished by vertically-striped garments, and ceilings are apparently raised by horizontally, and lowered by vertically-striped wall paper.

Fig. 4 gives another illustration of the same law. The subdivided half of the line appears longer than the undivided half, because the movement of the eye is delayed by the division marks.

Now if an unruled square (Fig. 3) is observed closely its height appears slightly greater than its breadth, although there is nothing to impede the free

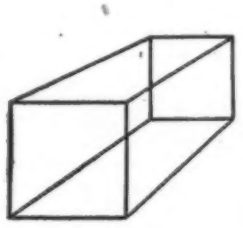


FIG. 8.

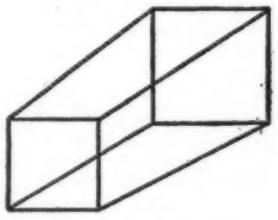


FIG. 9.

sweep of the eye over it in any direction. The explanation is that the eye, like the arm, moves more easily and rapidly in a horizontal than in a vertical direction. For this reason the apparent excess of height over breadth, in Fig. 2, is greater than the apparent excess of breadth over height, in Fig. 1.

These examples show that the visual estimate of a distance is based on the time and labor involved in glancing over the distance, as perceived and transmitted to the brain by the sensory nerves of the ocular muscles. Stone cutters, cabinet makers and many other artisans acquire, by long practice, remarkable certainty and precision in this unconscious operation, so that they can gage moderate lengths to 1/10 or 1/25 inch.

Pupils in drawing acquire such precision very slowly. Hence it is preposterous to set beginners to copying geometrical and symmetrical figures which they cannot draw with any approach to accuracy without the use of rulers or other unlawful aids.

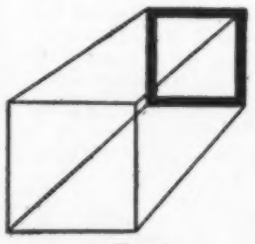


FIG. 10.

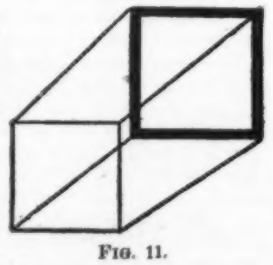


FIG. 11.

The estimation of volume, which includes that of distance in the line of sight, requires a closer analysis. The drawing master teaches that both the vertical posts of a fence and the horizontal intervals between them appear, and therefore should be drawn, smaller in proportion to their distance from the eye. The intimate connection of this and other laws of perspective with the facts described above becomes manifest on a little consideration. Suppose the lines *ab*, *cd*, *ef*, and *gh*, in Fig. 5, to represent four equal and equidistant posts, viewed by an eye placed at *o*, in the plane of the posts. The eye, in measuring the height of the nearest post by glancing along it from top to bottom, moves through the angle *aob*. In estimating the height of the second post the eye moves through the angle *cod*, which lies wholly within *aob*

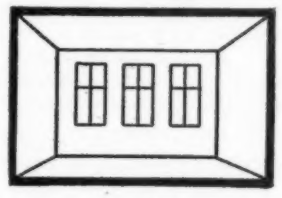


FIG. 12.

and is therefore smaller than that angle. So, for the other posts, the angle traversed diminishes as the distance increases. Hence as the eye does less work and occupies less time in moving through a small than a large angle, the more distant posts appear smaller in the proportion of their distance. This is neither an optical illusion nor a false judgment, but the natural consequence of the genesis of perceptions of length by unconscious deduction from the muscular efforts of the eye.

Our first notion of depth, in a picture or an actual landscape, is derived from the apparent sizes of objects. Of two essentially similar objects, the one which appears to be the smaller also appears to be the more distant. Thus Fig. 6 represents a railing perpendicular to the line of sight, and Fig. 7 represents a railing oblique to the line of sight and receding toward the right.

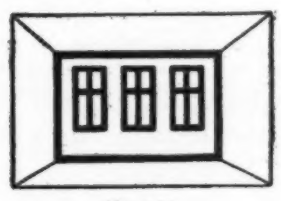


FIG. 13.

That the apparent differences in dimensions of similar parts are not the sole cause of perspective effect is shown by comparing Figs. 8 and 9, which would be identical if either were turned end for end. Fig. 8 apparently represents a transparent rectangular box whose equal ends appear unequal because one is more distant than the other, but to the average observer, at first glance, Fig. 9 suggests a box with unequal ends and with the small end toward the eye. This difference in interpretation is due to the fact that we are accustomed to viewing objects from above. By covering the right-hand square, looking with one eye through a tube and suddenly removing the covering (or even without these artifices) it is possible to convert Fig. 8 into a tapering box with its small end toward the eye and Fig. 9 into a box with equal ends,

FIG. 14.

but both of these boxes will apparently be seen, in an unnatural manner, from below.

The second most convincing evidence of depth or distance is distinctness of near and the indistinctness of remote objects. Hence if one end of each of the boxes is drawn in heavy outlines, as in Figs. 10 and 11, that end will appear to be nearer than the other. This effect is exhibited still more strikingly by Figs.

12 and 13. Even if all the lines were equally heavy, Fig. 12 would naturally be taken to represent the interior of a room, and the heavy outlines of the open side only strengthen this impression, but in Fig. 13 the heavy lines of the windows and the wall pierced by them completely reverse the perspective and bring the small side forward, to form an architectural monstrosity.

A third cause of the impressions of depth and solidity is found in the distribution and the varying intensity of light and shade. Light appears brighter and shade deeper in the foreground than in the background. Seen from a great distance, a white house or a blossoming cherry tree appears grayish, and black objects lose something of their blackness. Hence in painting, vivid contrasts of light, shade, and color are introduced in the foreground, while the background is painted in neutral or grayish tints, shading into each other without sharp outlines. The shadows cast by objects also heighten the effect of solidity. In Fig. 14 the indication of a shadow causes the heavy black line to stand out from the paper and suggest an upright stake in bright sunlight.

The perception of depth or distance is aided by the accommodation or change of focus of the eye in viewing objects at different distances. The crystalline lens becomes more convex when a very near object is regarded, and flattens for distant vision. These changes are required to throw the image, in each case, on the retina, and not before or behind it. The accommodation is effected by unconscious muscular effort. A still greater muscular effort is required in order to converge both eyes upon the same point, especially a near point. Stereoscopic or binocular perspective results from the variation of this convergence of the eyes for various distances and from the slight differences between the images formed on the two retinas.

Except for near objects, however, the perspective effects of both monocular and binocular accommodation are very small in comparison with the effects of relative size, light, shade and color, as is proved by the realistic impression produced by good photographs, paintings, panoramas, and especially by large projected pictures, moving or motionless.—Kosmos.

THE INVENTION OF THE PANTOGRAPH.

CHRISTOPH SCHEINER'S WONDERFUL DEVICE.

EVERY draftsman is familiar with the ingenious instrument known as the pantograph, with the aid of which any design can be copied with accuracy, in the dimensions of the original or on a larger or smaller scale. The pantograph consists essentially of four flat rods jointed to form a parallelogram (*ABCD*, Fig. 1), two adjacent sides of which are prolonged. Any straight line such as *PM*, which intersects all four rods is divided by their median lines into segments which preserve the same ratios to each other in all positions of the instrument. Hence if a pivot is placed at *P*, a tracing point at *N* and a pencil at *M*, and the pivot is

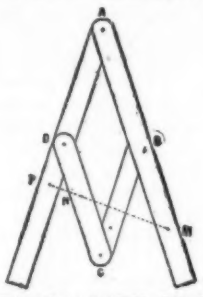


FIG. 1.—THE PANTOGRAPH IN ITS PRESENT FORM.

fixed by being pressed firmly on the drawing board while the tracing point is caused to follow the lines of a drawing, an enlarged copy will be drawn by the pencil.

The story of the invention of the pantograph is curious and interesting. The invention is three centuries old and is due to a Jesuit priest, Christoph Scheiner, who attained distinction by researches in physics and astronomy and who discovered sun spots independently of Galileo, if not before him. In 1631 Scheiner, who was then teaching in Rome, published a quarto volume of 100 pages, entitled: "Pantographice seu Ars delineandi res quaslibet per parallelogrammum lineare seu cavum, mechanicum, mobile." (Pantography, or the art of delineating all things with a

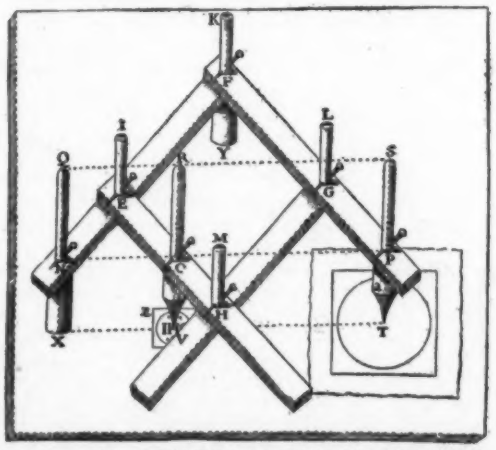


FIG. 2.—SCHEINER'S ILLUSTRATION (PUBLISHED IN 1631) OF HIS PANTOGRAPH (INVENTED IN 1603).

movable, mechanical parallelogram, straight or curved.)

This volume contains the whole theory and practice of the pantograph. The first part, comprising three-fourths of the volume, is devoted to the instrument for copying drawings which has been described above and to which Scheiner gives the name epipedograph.

In the second part of the volume the author explains a very ingenious and now almost forgotten application of the instrument, slightly modified, to the mechanical production of plane drawings of solid objects, statues, and landscapes. To the modified instrument Scheiner gave the name stereograph, and he naturally included both forms under the designation of pantograph, or universal drawing instrument.

It would be interesting to follow the author in his description of various possible forms of the instrument, especially the ingenious stereograph which, for the purpose for which it was designed, has never, to my knowledge, been surpassed, except by photography. But we are now concerned solely with the history of the invention, as Scheiner narrates it in his book.

In 1603, twenty-eight years before the publication of his Pantography, Scheiner, then thirty years of age, was teaching belles-lettres and mathematics in the college of Dilingen. Among his friends was an artist, whom he designates merely by his first name, George. The priest and the painter were so intimate that neither ever kept a secret from the other until one day the painter asserted that he knew a method of reproducing any drawing exactly, on any scale, without looking at the copy, but giving his entire attention to the original. Scheiner begged for an explanation, but the artist replied that the invention was "more divine than human and that he would not divulge it to mortals for any consideration." All the information that Scheiner could obtain, after much urging, was the statement that nothing was required except "a compass and a fixed center." "Seeing that I was speaking to deaf ears," Scheiner continues, "I resolved to adopt another course and to confide in God."

All this occurred in the beginning of the year 1603. Scheiner immediately went to work. His first idea was to use a wire; then he tried successively, in thought or in practice, a wooden rod, two rods, and finally four rods, forming a parallelogram.

During the night of January 19th-20th, the solution of the problem came to him. "It was like a flash of lightning," Scheiner writes. "To-day, after twenty-seven years, my memory of it is as fresh as if it had happened yesterday. On rising in the morning I returned thanks to God, and repeated in my heart Archimedes's shout of 'Eureka!' Then I joined my four rods with pins and made an enlarged copy of a picture of St. Ignatius, very accurately and without the least difficulty."

Scheiner made several other copies and sent them, with his pantograph, to the painter George, who proudly admitted that the instrument was far superior to his own, in which the relative positions of the fixed center, the tracing point and the pencil were invariable. George called Scheiner a benefactor of humanity but, rather inconsistently, warned him not to vulgarize his God-given invention by making it public. Scheiner showed the instrument to very few persons, but it was much talked of and so came to the knowledge of Duke Wilhelm of Bavaria, a talented artist, who summoned Scheiner to Munich and expressed great admiration for the invention. Subsequently Scheiner exhibited his parallelogram, or epipedograph, to his classes in mathematics, but he showed the stereograph only to a fellow priest and to one of his pupils, the Archduke Maximilian of Austria.

Finally, in 1631, Scheiner published the volume describing both instruments. Fig. 2, taken from that volume, represents the epipedograph, which differed in no essential particular from the pantograph of to-day. Few inventions have remained in use in their original forms for so long a time—three centuries.—Cosmos.

Rubber Oil (protection against rust).—According to a German this is prepared as follows: The crude oils, obtained by the dry distillation of brown oil, peat, or other earthy resinous substances, are subjected to a further distillation. Thin, rolled rubber (India rubber) cut into narrow strips is saturated with four times the quantity of this oil and left standing for eight days. The mass thus produced is subjected to the action of vulcan oil, or some similar substance, until a perfectly uniform, clear substance has been produced. This substance, applied in as thin a layer as possible to metal surfaces, forms, after drying slowly, a sort of pellicle, which is perfectly resistant to atmospheric influences.

INTERMITTENT SPRINGS.

THE conditions which give rise to the phenomenon of "intermittent springs" can be very neatly illus-

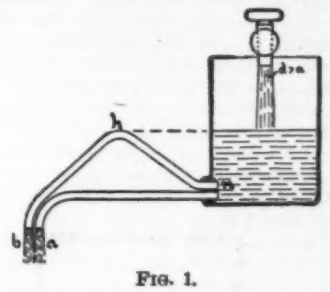


FIG. 1.

trated by means of the model shown in the accompanying diagram (Fig. 1). This model is readily constructed from very simple materials. Take a vessel having an opening at or near the bottom, and insert into this opening a stopper provided with two perforations. Into the lower of these fit a tube shaped as indicated (*a*), serving as direct outlet. Into the upper perforation fit another tube, to which a knee-shaped bend has been given, so that it can discharge, under suitable conditions, by siphon action. Its highest point *h* should be below the top of the vessel. Now feed a steady stream of water into the vessel, at such rate that the tube *a* alone is unable to discharge the water as fast as it is fed in. The level in the vessel will consequently rise, until it reaches the height *h* of the bend in the siphon tube. As soon as this occurs, the second tube also begins to discharge, and if the feed is properly regulated (greater than the discharge from *a*, but less than the joint stream from *a* and *b*), then the level in the vessel will gradually sink, until it falls below the opening of tube *b*. At this instant the discharge from *b* will cease, the level of the water

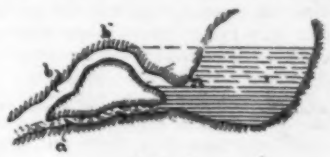


FIG. 2.

will steadily rise once more, and the entire series of events just described will be repeated time after time.

Fig. 2, which represents diagrammatically the structure of an intermittent spring in nature, will now explain itself. It may be added, that in case the lower channel *a* is entirely absent, the spring will not only show periods of abundance and of comparative subsidence, but will alternately discharge and entirely cease to flow.—Kosmos.

Discoveries of copper, gold, and silver are reported to have been made on the Fiji Islands, and Western Australian mining men are at Suva, Viti Levu, awaiting the publication by the local government of regulations under which mining may be carried on, after which the new discoveries will be thoroughly exploited. No mining on a commercial scale has ever been done on these islands.

FIREPROOFING WOOD AND TEXTILES.

SOME NEW INVENTIONS AND FORMULÆ.

CONSUL William H. Hunt, of St. Etienne, furnishes the following information concerning inventions for rendering wood and textiles fireproof, based on a recent report of Robine and Lenglen, well-known French chemists, the question attracting much public attention in France at present:

For years engineers and inventors occupied themselves with efforts to discover means by which textiles and wood could be rendered uninflammable, or at least incapable of transmitting flame. The methods proposed to this end are very numerous, but few, if any, afford absolute guaranty. A perfect method has yet to be found.

The oldest researches in this line date as far back as 1821, when Louis XVIII charged Gay-Lussac, a celebrated chemist, to make a practical study of the means of preventing fires and rendering scenic effects of theaters incombustible. The methods proposed since then are for the most part but modifications of those advocated by Gay-Lussac; however, it cannot be denied that a certain progress has been made in this direction. The study of these methods is interesting and certain of them deserve more than passing notice, as they have given some practical results, permitting one to augur a satisfactory solution of this important question.

By the word "ignifuge" is understood substances capable of communicating to cellulose material the property of becoming uninflammable or incombustible, or at least of depriving them of the faculty of transmitting flame. These substances are generally nonvolatile mineral salts, neither fusible, deliquescent, nor hygrometric. The salts are dissolved in portions mentioned further on and frequently mixed with other substances to increase their power of adherence. The objects to be rendered fireproof are either steeped in these solutions or the liquid is applied to them with a brush. The salts most commonly employed are phosphates, tungstates, borates, and particularly ammoniacal salts, boric acid, chlorides of calcium, magnesium, zinc, silicate of soda.

Herr Lochtin, a German chemist, studied the effect of the different salts on the combustibility of tissues, and he found that preference should be given to sulphate of ammonia, phosphate of ammonia, chlorides of ammonia, and zinc, alum, borax, boric acid, and alumin—the latter a precipitate of aluminate of soda. According to the author, the first three named, together with aluminate of soda, were the ones that gave the best results; the ammoniacal salts, volatilizing under the influence of heat, form, with the combustible gases, mixtures completely incombustible. The same might be said of chloride of calcium, magnesium, and zinc, while the action of alumin is purely mechanical.

The following substances would, according to Lochtin, possess but few qualities of combustibility: Borate of alumin and zinc, phosphates of lime and magnesia, zinc, soda, tungstate of ammonia, sulphates of magnesia, acetates of soda and potash; while the sulphates, sulphites, hyposulphites, silicates, carbonates of zinc, lime, magnesia, and ferrous sulphates increase combustibility.

Without pretending to discuss the value of the experiments of the German chemist, it is only correct to say that several of these substances, and particularly silicate of soda, have been employed with success.

The simplest method, especially for textiles, recommended in 1889 by the Paris Board of Fire Commissioners, consists in steeping the materials in a 10 per cent solution of phosphate of ammonia, after which they are wrung out and placed to dry in the open air. The cloth is rendered a trifle stiff, but when exposed to the action of a flame it blackens without taking fire. This method is particularly appropriate for the flimsy material worn in certain religious ceremonies, at balls, theaters, etc.

The Abel Martin method dates from 1879; presented before the Academy of Sciences, it received the felicitations of that learned assembly. The process is based on the employment of salts of ammonia to which is added a certain proportion of borax and boric acid. Successful experiments were made in 1881 before a large assembly of people, and the process was adopted for rendering fireproof the scenic decorations of several theaters of Paris. The formulæ of the Martin process follow:

For textiles: Sulphate of ammonia, 8; carbonate, 2.5; boric acid, 3; borax, 2; starch, 2; dextrin, 0.4; water, 100. The textile to be treated is steeped in this solution warmed to 86 deg. F. After rinsing, it is put to dry in the air. A quart of the liquid is sufficient for 12 square yards.

For wood: Hydrochlorate of ammonia, 15; boric acid, 5; gelatine, 50; chalk, 1.5; water, 100. The coating is applied with a brush, at a temperature of 140 deg. F.

For wood, straw, calico, and wrapping paper: Chloride of ammonia, 15; boric acid, 6; borax, 3; water, 100. The articles are steeped for 15 or 20 minutes in this solution, heated to 140 deg. F.

For paper: Sulphate of ammonia, 8; boric acid, 3; borax, 2; water, 100. Impregnation is made at a temperature of 120 deg. F.

The formulas of Venat and Herard differ but slightly from the foregoing, and the same might be said of those of Schneider. Bastvoirtz recommends the following mixture, which is claimed to have the additional virtue of rendering the textiles impermeable: Amphibolin, 34; glue, 2; chrome alum, 2; sulphate of ammonia, 2; water, 100.

Beaulieu Narconnay impregnates wood with a solution of polyboric salts in an excess of ammonia. Silicate of soda is very generally used on account of its cheapness for outhouses, partitions, boxes, barrels, etc. One of several coatings of a 10 per cent solution is rapidly applied with a brush; it is also used with other substances. Benevot incorporates silicate of soda (45 parts) with a solution of rosin (45 parts) in 100 parts of sulphide of carbon. Alumin salts have been recommended for incombustion. Ferrel obtained a coating by adding a carbonate to a solution of sulphate of aluminium.

Some authors employ coatings of a base composed of tungstates or stannates. Persin and Whipp steep the textiles for an hour in a solution of stannate of soda at 14 deg. Baumé. After drying they are put into a bath composed of the following parts at degrees Baumé: Tungstate at 35 deg., 4; citric acid at 9 deg., 1; hydrochlorate of ammonia at 4 deg., 3; acetate of zinc at 17 deg., 17. After being dried a second time the tissue is passed through cylinders heated by steam to expel the organic acid.

Mention might be made of the coating of amiante employed in the London theaters. This substance, which possesses remarkable incombustible qualities, is mixed with paint or with silicate of soda or glycerin. The wood painted with this composition burns slowly, like niter paper, and never gives out a flame.

All these methods, however, give but partial satisfaction, as the materials, although incombustible in themselves, do not possess indefinite durability. Through atmospheric influences and wear and tear the coating falls into dust and must be frequently renewed. Moreover, certain of these substances possess the grave defect of affecting the color. However, for textiles nothing better has been found. Not so for wood, say Messrs. Robine and Lenglen. To operate properly, wood should be treated while green—that is, immediately after it is cut down—so as to impregnate by the process of osmosis the cells of the fiber. Several inventors propose as many methods, but all with a view of saturating the wood with the mineral solutions.

Payne (1841) brought forward a process consisting of placing the wood in recipients in which a vacuum was created and then introducing a solution of sulphate of iron; when this had well penetrated the pores of the wood a solution of chloride of lime was added. By double decomposition sulphide of lime was formed, which filled up the cells. This process, with the addition of a salt of zinc, is still more or less used in the United States.

Thilmanz employed an analogous process, using solutions of sulphate of copper or zinc and chloride barium. Hely impregnated the wood with a concentrated solution of bisulphate of lime, and finally, with a solution of lime so as to form a monosulphide, which, oxidizing under the influence of the air, produced sulphate of lime that filled up the pores of the wood.

Hasselmann (1896) diminished notably the combustibility of wood by heating it first in a bath of sulphate of iron and sulphate of alumin, then in chloride of calcium, to which he added a milk of lime. The operation lasted six hours at a temperature of 280 deg. F. The cost of this method, it appears, was very low.

The Nodon-Bretonneau process involves the use of electricity. The wood is placed in large reservoirs containing the following solution, in percentages: Borax, 10; rosin, 5; carbonate of soda, 0.75. The wood is placed on a plate of lead communicating with the positive pole of a dynamo; the negative pole is connected with a similar plate at the upper end. Under the influence of the current the sap mounts, while the preserving solution takes its place. The operation lasts eight hours; the wood is afterward dried.

Within the last few years there has been a tendency to return to the ammoniacal salts, which, as has been seen, appear to have given the best results as regards incombustibility. The salts most employed are the sulphate, and especially the phosphate of ammonia in solution, which are injected under pressure into the wood.

It may be mentioned that in England a company has been formed for the manufacture of incombustible wood to be used on war vessels. It is understood that a similar company exists in the United States.

As to the stability of the agent of incombustion, opinions are divided. Some maintain that, the salts employed being stable in themselves, the qualities of incombustibility persist, while others affirm that the wood gradually loses this property and in the end combustibility is more or less increased. In any case, the treatment mentioned protects the wood from insects and decay.

PAINT FOR IRON SHIPS.

A GOOD paint for iron, steel, or otherwise covered parts of ships exposed to the water shall, in addition to preserving the material generally, serve the purpose of preventing the known injurious effects of accumulations of sea animals and algæ. This is obtained by a closely adhering, smooth coating, which contains, mixed with it, poisonous substances that kill the plants, mollusks, and other organic formations that attach themselves to the ship's hull and which also possess the property of peeling off in a thin layer where the dead organisms are situated, without exposing the hull of the ship. The coating substance is prepared as follows: I. Take 10 parts of copal, distill it until about 20 per cent has been driven off in the form of vapors, condensing these vapors in a special receptacle. During distillation the mass must be kept thoroughly stirred by means of a suitable stirring apparatus. After the above percentage of oil and water has been distilled off, the remainder of the copal, the greater portion, amounting to about 80 per cent, is withdrawn from the still and caused to cool in the quickest manner possible, which is best effected by immersion in cold water. After cooling, the mass is pulverized and dissolved in the sand bath in 96 per cent alcohol, the temperature during this process being kept as low as possible. The varnish thus obtained is filtered, and after the copal oil, distilled off, has been previously added to it, it is diluted with alcohol. The addition of the water carried over in distillation must be scrupulously avoided, as otherwise precipitation would immediately occur. Then the following alcohol solutions are prepared: 2 parts of pulverized aloes in 4 parts of 96 per cent alcohol, 2 parts of camphor in 4 parts of 96 per cent alcohol, 2 parts of pitch in 4 parts of 96 per cent alcohol, and 5 parts of rosin in 3 parts of 96 per cent alcohol. These four solutions are mixed in a large receptacle with the solution first prepared, cleared by precipitation and drawn off from the sediment. Of this carefully prepared solution take 33 parts and while constantly stirring add 28 parts of colcothar and 3 parts linseed oil together with 3 parts of castor oil, after long stirring, also 10 parts of *hydrargyrum oxydatum rubrum* or *flavum*, stir it continuously for 12 hours, add 5 parts of crystallized carbolic acid, stir it for a further 12 to 24 hours and then draw it off into barrels. II. To protect the keel of a vessel against fouling and destruction by insects it should be coated twice with the following paint: 16 parts of tallow, 2 parts of yellow wax, 3 parts rosin, 2 parts of glass sand, 0.25 part of arsenic are melted together, and while stirring, a suitable color added. It is advantageous first to coat the sides or walls with varnish.

Although steel collector rails have always been used where a third-rail system of traction has been adopted, states a contemporary, it is only recently that an attempt has been made to use steel trolley-wires for the overhead collection of current. The obvious objection to a steel wire is its great size and weight, if it is to carry the heavy currents necessary in electric traction. On the electrified portion of the New York, New Haven, and Hartford Railroad a copper trolley-wire was originally used, but wore kinky at the suspension points. A steel wire was then added, from which actual collection took place, but the original copper trolley wire was retained to do most of the transmission, the steel and copper wires being in parallel, and connected at intervals of 10 feet; the steel collector is, in fact, suspended from the copper wire. The wear of the collector wire after six months' operation was only one per cent of its depth. The trolley current in this case is alternating. The trouble with the copper trolley wires at the suspension points seems to be most serious at high speeds.

THE COSTLIEST RAILROAD IN AMERICA.

A NEW RAILROAD THAT COST MORE THAN THIRTY MILLION DOLLARS.

BY J. O. LEWIS.

THIS is the story of a great railroad. It is the Carolina, Clinchfield & Ohio Railroad, just completed from the great bituminous coal fields of southwestern Virginia and eastern Kentucky to the cotton mill district in South Carolina. The promoter and builder of this magnificent road is George L. Carter. To-day it stands as a monument to his genius—one of the greatest pieces of railroad construction east of the Rocky Mountains.

It is the only road which crosses the entire Alleghany Mountains at their widest part transversely, or at direct right angles with their parallel ranges. Rising from a few hundred feet above the level of the sea to 2,629 feet, at the highest point, where it crosses the Blue Ridge Mountains, exceptionally low grades have been maintained. From Dante, Va., the present northern finished point, to Bostic, N. C., its present southern terminus, the distance is 211 miles; and for the distance it contains more tunnels than any other road in the country. There are thirty-five tunnels, six important bridges, and many very large cuts and fills; but in the main, bridges and trestles have been done away with, and wherever possible, replaced by fills.

Take a map showing eastern Kentucky, southwest Virginia, eastern Tennessee, and western North Carolina; then locate Elk Horn City in Pike County, Kentucky, near the Virginia line, which is the nearest town of any size to Dante, Va.; next draw a straight line through to Marion, N. C., *via* Johnson City, Tenn., and you have the route of the C., C. & O. Railroad—directly across more mountain ranges than any other section in the Alleghany system.

The purpose of the road is to furnish an outlet for the product of the Clinchfield coal mines, principally to the southeast Atlantic seaboard, nearest the Panama Canal and southern coaling stations.

The original idea and purpose of George L. Carter, president of the road, when he purchased the unprofitable line of the old "Three C's" in 1901, which ran only from Johnson City, Tenn., to Huntdale, N. C., was to extend it into the great bituminous coal fields of southwest Virginia and eastern Kentucky; and to make it the best ballasted, safest, and largest coal-carrying road in the United States.

Looking backward into the history of the old "Three C's"—Chicago, Cincinnati & Charleston Railroad—we find that the promoters of this road were Gen. John T. Wilder, now living at Knoxville, and Frank Stratton, a Virginian. Their idea of constructing the road was to build a trunk line from Chicago to Charleston, and put it on foot in 1882. Within two years a line was constructed from Allison's Mills, Tenn., on the Watauga River to the North Carolina State line, a distance of about thirty miles. In 1890 it went into the hands of receivers, and was sold to Samuel Hunt, then president of the Cincinnati, Portsmouth & Ohio Railroad. That portion of the line from Allison's Mills to Johnson City was torn up, and the material used to extend it farther south, and to a station called Huntdale, named for the president. In 1901 George L. Carter purchased this short line, reorganized it, and changed the name to the South & Western. With Mr. Carter the road was to be but the means to an end. He had early inspected and practically gone over every foot of the route, was familiar with the topography of the country, knew of and realized the value of the mineral deposits, had located every tract of timber, and figured out the possibility of big returns in its development.

He took his proposition to New York and interested capital. The services of M. J. Caples, an expert civil engineer and practical railroad builder, were secured, and the plans begun for building—which has been proven—one of the best and most costly railroads for the distance in the United States. Not costly in the meaning of extravagance, but costly from physical necessity, for the greatest experts of the country say that it has not cost a dollar too much. The actual building began in 1903, and was finished in November, 1908.

Instructions were given to the engineers that surveys be made which would give the road the lowest possible grade and yet the shortest route to the coast. To do this was the riddle which has just been solved in the finishing of the line from Dante to Bostic. In celebration of its completion, the Commercial Club of Johnson City, Tenn., gave a large banquet to the officials, which was attended by many prominent men of the country, including W. W. Finley, president of the Southern; F. P. Howe, Philadelphia, president of the East Tennessee & Western North Carolina Railroad; and presided over by Congressman W. P. Brownlow of the First Congressional District of Tennessee as toastmaster.

To handle big trains of large cars of coal meant to do away largely with trestles and bridges and to substitute fills wherever possible, and to build a low-grade road. As a result there are not more than a half dozen bridges, and the grade maintained is a compensated grade of less than six-tenths of one per cent a mile over the summit of the Blue Ridge. Bridges were built only where it was impossible to make fills.

From Dante, Va., to Bostic, N. C., a distance of 211 miles, there are thirty-five tunnels, the sum total of the lengths of each making more than seven miles of underground travel. The longest tunnel on the line is through Clinch Mountain, bearing the same name. It is 4,200 feet long, and cut through solid rock the entire length. It took more than two years to drive it and cost over two million dollars. The next longest tunnel is right on top of the Blue Ridge Mountains at Altapas, N. C., and is known as the Summit tunnel. This tunnel is more than a half mile long, and is 2,629 feet above sea level. From Spruce Pine, two miles west of Altapas, to Marion, N. C., there are twenty-odd tunnels.

After passing through the Summit tunnel, the line makes an eight-mile loop, returning to within four hundred yards of the south end of the tunnel, but three hundred feet lower down. In this eight-mile loop there are nine tunnels, and from within twenty miles of the Summit tunnel there are nineteen tunnels. A very important feature about the tunnels on this line is that every one is cut high enough to permit the tallest man to stand on top of a box car as the trains pass through. From the 211-mile post on the west side of the Blue Ridge to the 231-mile post on the eastern slope, the rise or fall vertical is 1,160 feet.

The cuts and fills are almost innumerable, while some of them are the largest and deepest to be found on any road east of the Mississippi River. The highest trestle is over Copper Creek in southwest Virginia, and is known as the Copper Creek viaduct. From the surface of the stream to the track or rails on top of the trestle the height is 185 feet, and its length is 1,160 feet. Another very high bridge is over Holston River, one of the headwaters of the Tennessee, the height of which reaches 100 feet. The largest and deepest fill on the line is known as the Knob Creek fill, being 85 feet deep and three-quarters of a mile long, requiring more than a half million yards of material to fill up to grade. The next largest fill is over Gate branch, which reaches a depth of 135 feet and 1,200 feet long. The Big Poor fill is another one of considerable cost. This fill is a mile long, and required more than 200,000 cubic yards of earth.

The largest and most important cut on the road—and said to be the largest on any road in the South—is the Soldiers' Home cut, located right at the junction of the Home grounds and the Southern Railway. This cut is 85 feet deep, a mile long from grade ends, and required the removal of more than 500,000 cubic yards of dirt, most of which was used to make the Knob Creek fill, which is only two miles distant.

The most rugged and picturesque portion of the road is that part which runs from Johnson City south across the Blue Ridge Mountains to Marion, N. C., and known as "The Land of the Sky." Beginning at Unaka Springs, twenty miles south of Johnson City, the road enters and runs through the famous Nolachucky Canyon, said to be the grandest outside of the Grand Canyon itself. Like a serpent for nearly twenty miles, this road winds its way through chasms, gorges, ravines, between towering cliffs and mountains extending upward thousands of feet.

After leaving Altapas and the Summit tunnel for about four miles, the line passes in full view of Mount Mitchell, the altitude of which is 6,711 feet above sea level.

"Twelve miles from this point is Linnville Falls Station, from which Linnville Falls, N. C., a noted summer resort, is reached in covering a distance of six miles by stage. This is a charming resort, high above the clouds. From this point can be seen twenty-one peaks higher than Mount Washington, and forty-eight that overtop Mount Adams. The stage route from Linnville Falls Station on the C., C. & O. Ry. passes through some of the wildest scenery of the South; vast chasms, ghastly rents, massive towering rocks, seared and seamed, are on every hand. At this point a stream dashes over a steep, broken cliff some hundred feet high. There is most excellent trout fishing to be had at this point." (Charles T. Mandel in Appalachian Trade Journal.)

Where the famous loop is made on the eastern slope of the Blue Ridge, there are three complete views of the track on one mountain side as it winds its way back and forth to make the grade. This is said to be the most remarkable loop on any road in the United States. This feature was considered practically impossible at one time; but the courage of the owners and the skill of the engineers accomplished the miraculous, and have proved nothing impossible in railroad building.

Standing at the mouth of Summit tunnel, one can see the train as it winds its way around the mountain sides, through many tunnels and cuts, crossing the valleys, puffing and blowing in the climb, for thirty-five minutes before it reaches you. Fourteen different views of the train are presented in this scene. Across the valley on the side of another great mountain can be seen the three Washburn tunnels in straight line, and to stand at either end, one can see through all three of them. It is indeed a spectacular sight, and with perhaps but few exceptions, unequaled on any road and anywhere.

The Blue Ridge section is one of the richest in iron, copper, mica, kaolin, manganese, limestone, and timber in the whole Appalachian region, if not in the whole country. Southeast of the Blue Ridge, and embracing part of it, lies the Piedmont section, stretching out into the great southeastern cotton mill district; and through the very heart of these penetrates the Carolina, Clinchfield & Ohio Railway. With such immense undeveloped wealth, together with that which is just yet in the embryonic and nursery stages, no one can gainsay the wisdom prompting the vast expenditures made in the development of this road and its co-related interests.

The average cost per mile of the C., C. & O. Railway has been upward of $125,000.

From Bostic, N. C., to Spartanburg, S. C., the building is well along toward completion, and by October next through trains will be running into Spartanburg.

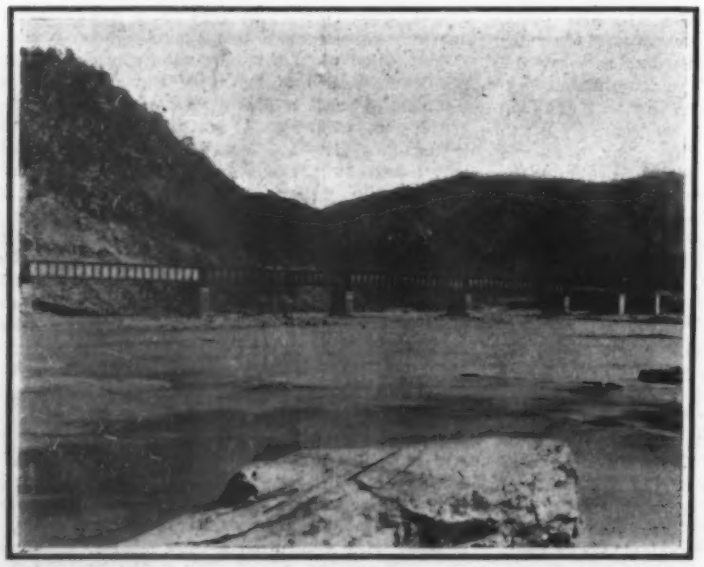
To give one an idea of the economic considerations entering into the future management of the road, we will state that the road is now hauling in one train from the coal fields at Dante through to Bostic, with one engine, what it takes the Seaboard to haul out of Bostic in three loads. These large engines were made by the Baldwins.

MANUFACTURE OF ENAMELED LEATHER

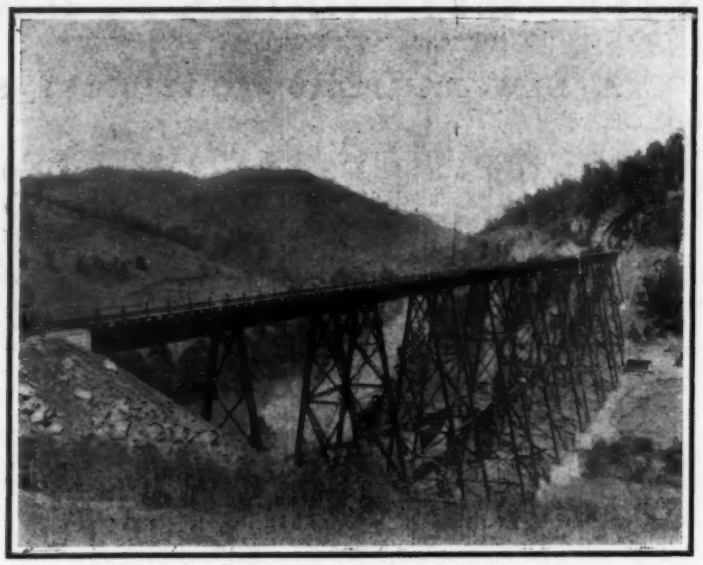
THE properties required of a good leather varnish are that it shall combine intimately with the leather, dry well, be flexible when cold, and be waterproof. For the preparation of such a varnish it is necessary to use perfectly pure linseed oil that has been freed from palmitin by treatment with fuming nitric acid. The oil should have been kept for a long while. Its age may be recognized by its pure yellow color and transparency, while new oil has a green and turbid appearance and contains more water than old oil contains. The oil is first heated in an iron vessel to 150 deg. C. (302 deg. F.) until foaming ceases, and is then heated to 250 deg. C. (482 deg. F.). Under this treatment it assumes a blue green color. Any fibrous scum should be carefully removed. On the following day the oil is heated rapidly to 350 deg. C. (662 deg. F.) and kept at this temperature for 6 hours, for the purpose of thickening it. Its condition is tested by the hard and vitreous character of a sample dried on a glass plate and by the rapidity of drying. If a specimen, furthermore, leaves no grease spot on paper the oil is quickly cooled to 150 deg. C. (302 deg. F.) and then mixed with 3 per cent of litharge or 1.5 per cent of manganese borate. The brilliancy and hardness are improved by adding, at the temperature of 250 deg. C. (482 deg. F.) 5 per cent of melted brown Umbra copal or 10 per cent of Angola or Kauri copal. After adding lampblack or diamond black, a first coat of the varnish is applied to the grain side of the leather and, when dry, is polished with pumice stone. The second coat of varnish is then applied, and after it has been dried in an oven at 40 or 50 deg. C. (104 to 122 deg. F.) the final coat is applied, in a place free from dust, with a horse-hair brush or a varnish sprayer.

THREE TUNNELS, ONE SHOWING THROUGH THE OTHER.

LOCAL FREIGHT AT GUEST RIVER, VA.



BRIDGE AT UNAKA SPRINGS, CHUCKEY RIVER. FOUR SPANS 117½ FEET; THREE SPANS 70 FEET.



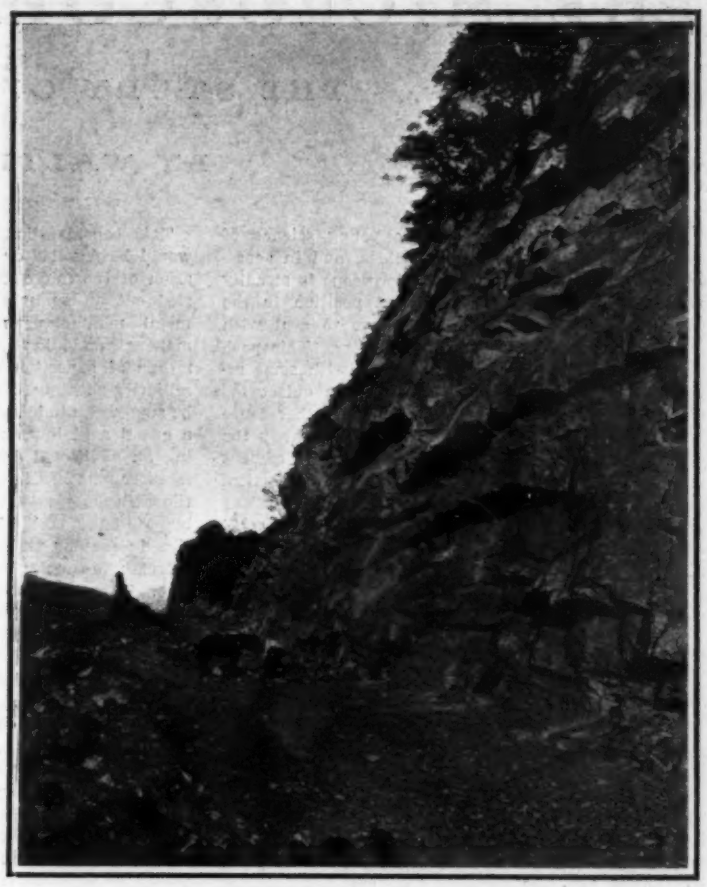
COPPER CREEK VIADUCT, 185 FEET HIGH, 1,160 FEET LONG.

EAGLE CLIFFS IN THE GORGE OF CHUCKEY RIVER.

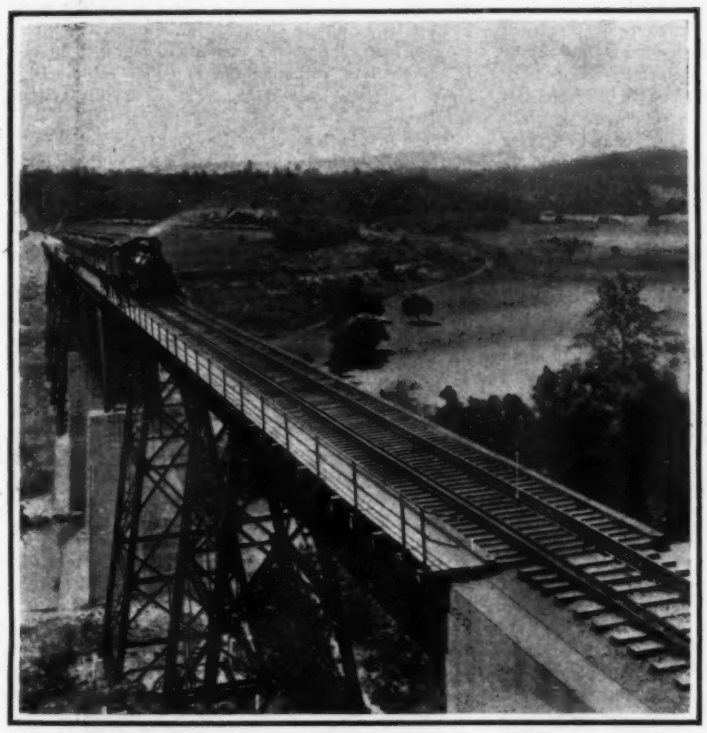
THE SANDSTONE BLUFFS ALONG THE CLINCH RIVER ON THE EDGE OF THE COAL FIELDS.

THE COSTLIEST RAILROAD IN AMERICA.

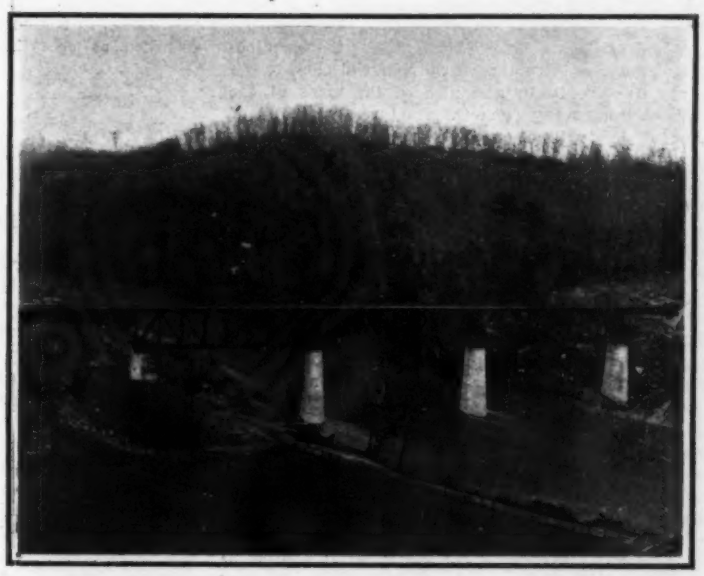
DEVIL'S BACKBONE IN THE CENTER, WHICH IS THE STATE LINE SEPARATING TENNESSEE AND NORTH CAROLINA.



MAKING THE ROADBED ALONG THE CLIFFS OF CLINCH RIVER ABOVE CLINCHPORT, VA.



THE CATAWBA RIVER VIADUCT.



BRIDGE ACROSS THE NORTH FORK OF THE HOLSTON RIVER.

THE FILL OVER THE HOLLY SPRING BRANCH.

SOLDIERS' HOME CUT, 85 FEET DEEP, ONE MILE LONG, AT JOHNSON CITY, TENN.

THE COSTLIEST RAILROAD IN AMERICA.

THE MICROSCOPE IN ENGINEERING.*

THE STUDY OF FAULTY METALS.

BY WALTER ROSENHAIN.

DURING the past ten years the young science of metallography has made rapid strides, and in consequence of this development the microscope is steadily assuming an increasingly important position in the testing-laboratories of those who have to deal with metals, either as manufacturers or users. This position has, however, been accorded to it with some reluctance, partly, perhaps, because at the outset too much was claimed for the instrument. Another cause is to be found in the fact that, as is necessarily the case in all young sciences, theoretical development has outstripped practical application, and practical men are too apt to regard anything "theoretical" as practically useless. But even if we leave aside all questions of the promising future applications of these theoretical discoveries, a mass of purely practical results is now available in which the microscope has clearly demonstrated its immediate value.

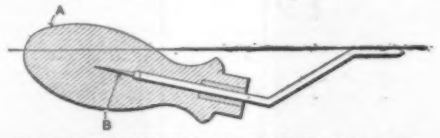
Perhaps the most fruitful field for the application of the microscope in the present state of our knowledge of metals is the study of the nature and causes of breakages or other failures occurring in practice. That the thorough clearing up of such cases, wherever possible, is eminently desirable, both in the interests of the parties immediately concerned, and also for the sake of the general advancement of our knowledge, is so obvious that it need not be further insisted upon. It is just where our accepted knowledge and our usual practice go wrong that the field for fresh discoveries lies before us. The methods that are available for the *post-mortem* examination of breakages must depend very much upon the nature of each particular case; experiments that are possible with the broken end of a 12-inch shaft are not applicable to a small brass condenser tube. In every case, however, the first, and perhaps the most vital, step is the examination of the micro-structure of the material close to the actual fracture itself, and also of the mass of the material lying away from the fracture. The first of these sections will often show whether there is any special local weakness in the metal at the point of actual fracture, or whether the fracture itself displays any particular characteristic, for it is well known that the path which a fracture takes among the micro-constituents of a metal depends on both the nature of the metal and the manner in which the fracture was produced. In a given material, for instance, the section of a tensile or bending fracture is quite different from one produced by shock or by repeated alternations of stress. The difficulty about these observations lies, however, in preparing an actual section through the fracture, as this is usually either corroded or worn by subsequent friction; when it is clean and fresh, however, the actual fracture may be embedded in a thick deposit of electrolytic copper, and a satisfactory section may be cut through the compound mass thus formed.

Apart from the examination of the fracture itself, the general micro-structure of the material will, as a rule, reveal whether it has been subjected to any undue treatment during manufacture or use. Thus excessive heating, whether by exposure to an unduly high temperature or to a more moderate temperature for an unduly long time, leaves its trace in the form of a coarse, angular structure which is readily recognized in such materials as steel, brass, or bronze. Insufficient rolling or forging, or working at either too high or too low a temperature, can also be readily diagnosed. In many cases a useful guide can be obtained by comparing the micro-structure of the object which has failed with that of a similar object which has given good service; but this is only necessary where the material in question is one which has not been thoroughly studied, so that the effects of various forms of treatment on the micro-structure are not so definitely known as could be desired. Fortunately, the list of such materials is rapidly diminishing, but, owing to the wide range and complexity of industrial alloys, cases of this kind will continue to occur occasionally.

Although the microscopic evidence is, as a rule, quite conclusive, it is eminently desirable to supplement it wherever possible by the data of a careful chemical analysis and complete mechanical tests, dynamic as well as "static." Even where these additional data are not needed to confirm the conclusions drawn from the microscopic examination, they are valuable as throwing a light upon the indications of the various forms of test relied upon by engineers in drafting their specifications.

This consideration raises the question how far it would be possible or desirable to include an examination of the micro-structure in the regular tests carried out on engineering materials. Some time ago metal manufacturers, and more particularly steel makers, would have met such a proposal with every means of opposition in their power, but greater familiarity with questions of micro-structure has, it may be supposed, diminished this feeling. If it were simply a question of imposing an additional test, or of placing an additional difficulty in the way of the manufacturer who has to comply with specifications, a hostile attitude would, of course, be readily understood, but the effect of the inclusion of microscopic examination in regular testing would not be at all likely to increase the stringency of the specifications in question. Thus, as regards chemical compositions, specifications are so drafted that, even with unfavorable structure, the material may be strong enough to meet the mechanical requirements of the engineer. Were it possible to rely upon obtaining a favorable structure in the material as used, the necessity for stringency in regard to composition would be materially reduced.

Further, the use of the microscope in this connection should enable the engineer to rely more securely upon both the uniformity of his materials and on their conformity with the test specimens. The reason is that, by the microscopic examination of a number of very small pieces chosen from a variety of different pieces or parts of the material, it would be at once ascertained whether the material was uniform, and whether the test-pieces chosen for mechanical testing or for chemical analysis fairly represented the bulk of the material. This again is an application of the microscope in engineering practice which could not be regarded as operating against the interests of the



SCREW-DRIVER FOR RAPID ACTION.

makers of the material; the rejection of metal on the results of tests carried out on samples which happen to be below the average of the batch would be prevented quite as often as the acceptance of a batch on results obtained from an unduly favorable sample.

In the case of large pieces of metal also, the application of the microscope would prevent the occurrence of failures which sometimes arise as a consequence of want of uniformity in the materials forming different parts of the same forging. Such differences may arise either from segregation, i. e., from a non-uniform distribution of the constituents or the impurities in the metal as originally produced, or it may be the result of insufficient or of wrongly applied working. Thus, if rods of ductile metal, such as brass, are drawn down cold too rapidly, or if the reduction at each pass through the dies is incorrectly adjusted, the result is the production of a surface layer of material which has been much more heavily deformed than the core of the rod, and this results in a condition of serious internal stress which may even produce subsequent spontaneous fracture.

In large forgings also, an external layer of fine-grained material is sometimes found superposed on a coarse-grained core as the result of inadequate working. This also is liable to lead to failure in use, while the indications of test-pieces cut from the fine-grained layer are entirely falsified by the real behavior of the piece as a whole.

Examples of other uses of the microscope in connection with the materials of engineering could be given in great numbers. Perhaps one of these which is already most appreciated in practice is the use of the instrument to control the annealing processes in connection with copper and its alloys. The whole history of the constitution and structure of the more important alloys of copper with one added element at a time has been worked out and embodied in what appears at first sight to be highly theoretical "equilibrium diagrams." These diagrams, however, enable us to understand the precise effect produced upon the constitution and structure of any of these alloys by thermal treatment. The structures resulting from exposure to certain temperatures, followed by either slow or rapid cooling, have been determined, as well as the particular properties of the alloys which correspond to these structures. An understanding of these diagrams therefore enables the manufacturer or user to treat his alloys at the proper temperatures, and to control the results with ease and certainty by examining a few specimens of the metal under the microscope and noting the type and the size or scale of the structure.

At the present moment the control of these processes is only satisfactorily available for those groups of alloys the constitution of which has been fully investigated, but this is so far the case only for binary alloys —i. e., those consisting of two metals only. The majority of industrial alloys are much more complex, and for these the theoretical guidance is not yet available, principally because the complete study of these complex systems is a matter of much greater difficulty than that of the simpler binary series. The fullest benefit of the microscope will therefore only become available for workers who deal with the complex alloys when the purely scientific investigations have covered this difficult ground; but meanwhile it is quite possible in practice to obtain empirical data as regards the best micro-structure and the treatment required to obtain it. Such data, although not of equal value with the more complete knowledge, form a useful temporary substitute.

These few indications of the present practical utility of the microscope in connection with engineering materials, while very far from covering the whole range of the subject, may perhaps be enough to show that, even with existing knowledge, the instrument is capable of rendering—and is, in fact, rendering—the greatest service to engineering and metallurgical practice. These fruits are already derived from little more than twenty years of metallographic investigation. For the future of this young science, therefore, the highest hopes appear to be well founded.

* Nature.

A HANDY SCREW-DRIVER.

A CONTRIBUTOR to Wood Craft calls attention to a simple little tool which is handier than the ordinary screw-driver, particularly for putting in small long screws. It consists of a handle *A* in which is drilled a hole, so that a wire, say 3 inches long, will revolve in it without much friction. Into the bottom of the hole is driven a small brad *B* which is used as a bearing for the end of the rod constituting the screw-driver proper. The outer end, of course, is flattened to suitable dimensions. It will be seen that the tool constitutes a very neat little screw-driver, which will sink small screws very rapidly by simply revolving the handle like a crank, in the proper direction. A number of wires with different sized ends can be kept on hand, and interchanged as conditions require.—Machinery.

A NEW PRINTER'S ROLLER MASS.

ACCORDING to a German patented process, gelatine, glycerine, borax, bone oil, and stearine oil are melted together in suitable proportions and allowed to cool in proper molds.

Mass for Rollers for Job Printers.—60 parts of gelatine, 80 parts of glycerine, 1.4 parts of borax, 1.4 parts of stearine oil, 0.7 part of beef bone fat.

Mass for Rollers of Cylinder Presses.—50 parts of glycerine, 50 parts of gelatine, 1 part of borax, 1 part of stearine oil, 0.5 part of beef bone fat. The gelatine, before use, is mixed with 15 per cent of its weight of water. This printing roller mass is said to have the quality, in addition to greater durability, of not becoming useless after several re-meltings, but being always ready to be melted again, requires less time for melting over and is then more thinly fluid.

Substitute or Imitation Bronzes.—According to Vanino and Geiger, take for this purpose powdered aluminium and yellow organic coloring matter, such as gold orange. They are used with a varnish of the following composition, which imparts to the mixture the necessary brilliance: 50 parts sandarac, 10 parts mastic, 5 parts Venice turpentine, 135 parts alcohol. To obtain a golden substitute bronze, dissolve in it 0.4 part of metanil yellow and gold orange, add to this 20 parts of aluminium, finely pulverized and shake. For copper substitute bronze, take the above described mixture of resins and dissolve in it only 0.8 part of gold orange and add 20 parts of aluminium, whereby a beautiful copper color will be produced. 0.4 part metanil yellow, with the same quantity of varnish, produces a greenish bronze shade.

LIQUEFIED ILLUMINATING AND FUEL GAS.

MORE ABOUT BLAU GAS.

BY O. BECHSTEIN.

ELECTRICITY has by no means monopolized the field of illumination as was fondly hoped in the infancy of the electric light. On the contrary, the use of illuminating gas has greatly increased, especially since the invention of the Welsbach mantle. Gas is also largely used as a fuel on account of its convenience and, in many cases, its comparative cheapness. In Germany, for example, the production of gas increased from 700 million cubic meters in 1896 to 1,650 million cubic meters in 1906.

As, however, illuminating gas can be profitably produced only in large establishments, some efficient substitute for the latter has long been sought for small towns and rural districts. In this class belong the small and comparatively simple gas machines which produce such special forms of gas as acetylene, air gas, aerogen gas, benoid gas, oil gas, etc. But even these small plants are profitable only when the consumption of gas reaches a certain minimum, hence many attempts have been made to compress gases of high illuminating and calorific power and to transport them to the place of consumption in a highly compressed form in suitable vessels, which may be connected with the gas pipes through a pressure-reducing valve. Ordinary coal gas is not well adapted to this process, as even when it is greatly compressed its volume remains so great as to require large and heavy containers, and, consequently, to involve heavy freight charges. Some other gases are much more suitable for this use. Oil gas, for example, is largely used for lighting railway cars. It is carried on the cars in small containers under a pressure of six atmospheres, but for transport to great distances it is compressed into larger vessels at ten atmospheres. The compression of oil gas, however, causes some condensation and resultant loss of illuminating power. The cost of transportation of small quantities is also still high and consequently compressed oil gas is little used except for lighting railway cars and buoys.

Far more suitable than oil gas is a new gas obtained from mineral oil and called Blau gas, from the name of its inventor. This gas is manufactured in Oberhausen-Augsburg. When subjected to a pressure of 100 atmospheres it condenses into a colorless liquid which occupies only 1/400th of the volume of the gas and which may be packed and transported as cheaply and conveniently as petroleum, alcohol, benzine, and other liquid fuels.

Blau gas is obtained from the distillation of mineral oils in retorts. The oil is first vaporized in an upper retort, from which the vapors pass down into a retort at a higher temperature, where the Blau gas is actually formed. Thence the gas passes through a scrubber of the usual type into the compressor, where it is subjected to a pressure of 100 atmospheres. The liquefied gas is packed for transport in light steel cylinders.

The specific gravity of liquefied Blau gas is only 0.51. It is therefore considerably lighter than petroleum or alcohol (specific gravity 0.8) or benzine (specific gravity 0.7). This low density, combined with the very small volume of the liquefied gas, makes it possible to use comparatively light containers, despite the high pressure of 100 atmospheres, so that it can be sent to great distances at small cost. Another important point is that a small mass and volume of this fuel represent a large amount of illuminating and heating power. The maximum heating power of Blau gas is 12,318 calories per kilogramme (22,172 British heat units per pound), or 15,349 calories per cubic meter (1,719 heat units per cubic foot). The following table gives the heating and lighting powers of Blau gas in comparison with other gases.

Name of Gas.	Heating Power, Calories per Cubic Meter.	Heating Power British Heat Units per Cubic Ft.	Candle Power in Hefner Candles.
Blau gas	15,349	1,719	3,000 (incandescent)
Coal gas	5,000	560	700 (incandescent)
Acetylene	13,000	1,456	1,666 (Argand)
Air gas	2,900	325	500 (incandescent)

This table shows that Blau gas is by far the most valuable of all available illuminating and fuel gases. In chemical composition Blau gas resembles coal gas, as it contains, like the latter, hydrogen, methane, and other saturated and unsaturated hydrocarbons; but it is entirely free from carbon monoxide and is therefore not poisonous. The boiling point of the liquefied gas lies between —50 deg. C. (—58 deg. F.) and —60 deg. C. (—76 deg. F.).

The cylinders are of various sizes. The smallest contains about 1 pint or ½ pound, the largest about 100 pints or 50 pounds. The last-named quantity is sufficient to feed a pressure-incandescent burner of 50 Hefner candle-power during 1,238 hours. The proportional quantity of gas consumed by an incandescent burner, however, diminishes rapidly as the candle-power increases, as is shown in the following table:

Candle Power.	Blau Gas Consumed Grammes per Hour.	Hefner Candle Hours per Kilo of Gas.
50	21	2,400
100	35	2,850
250	72	3,500
500	122	4,100

Burned in an Argand burner, Blau gas produces a small and very bright flame, but it is preferable to use it in an incandescent burner, especially as the gas is furnished in a highly compressed condition, so that any desired pressure can be obtained by a reducing valve, and it is especially adapted to the inverted or reflex burner. The quantity of light then produced is much greater than can be obtained with the gas under the low pressure commonly used in city distribution.

A Blau gas apparatus consists of a sheet metal case which contains the gas cylinders, pressure regulator, manometer, safety valve, and the necessary piping. This case is surmounted by a cylindrical gas tank which daily receives the approximate amount for a day's consumption from the steel transport cylinder, and is charged to a maximum pressure of 2 atmospheres. If the manometer indicates a higher pressure than this the excess of gas escapes into the atmosphere through the safety valve. After the tank is filled the connection with the cylinder is cut off and a valve is opened between the tank and the pressure regulator, through which the gas flows to the distributing pipes. The function of the regulator is to keep the pressure constant in the pipes, despite fluctuations in consumption and the loss of pressure in the tank as the gas is consumed, and thus to prevent irregular pressure and flickering light. The apparatus occupies little room and can be set up anywhere, even in the open air. It requires only a few minutes' attention daily.

The use of compressed Blau gas is attended with very little danger. It has already been mentioned that the gas is not poisonous. It is also far less explosive than either coal gas or acetylene. All mixtures of air and coal gas containing from 6 1/2 per cent to 19 1/3 per cent of coal gas are explosive. With the more dangerous acetylene the range of danger extends from 2 to 49 per cent. With Blau gas, on the contrary, the mixture must contain between 4 per cent and 8 per cent in order to explode. Another advantage is the fact that the combustion of Blau gas produces only small quantities of products injurious to health.

The cost of Blau gas as compared with other illuminants is not high, as appears by the following table. In comparing the values given in the table it must be remembered that Blau gas is never a competitor with coal gas furnished by a large gas works, and that the apparently cheaper acetylene or air gas requires generating plants which involve large expense in addition to danger and inconvenience. Blau gas, on the contrary, is furnished clean and ready for use with the simple apparatus described above.

COMPARATIVE COST OF BLAU GAS AND OTHER ILLUMINANTS.

Illuminant.	Cost of 50 Hefner Candles per Hour.
Blau gas, incandescent.....	0.60 cent
Coal gas, incandescent.....	0.28 cent
Air gas, incandescent.....	0.31 cent
Acetylene	0.55 cent
Incandescent electric light.....	1.75 cents

For the illumination of villages, detached buildings, country mansions, etc., Blau gas in many cases is preferable to any other illuminant, and it is coming more and more into use for lighting railway trains, boats, automobiles, and other vehicles. In view of its very high heating power it is also very well adapted for use as fuel in laboratories, kitchens, baths, laundries, etc.

Blau gas has another wide field of application in autogenous welding where it may advantageously replace hydrogen and acetylene. For this purpose two cylinders are used, one of which serves merely as a portable gas tank, as the gas cannot be delivered to the burner at the high pressure of 100 atmospheres. The same arrangement is used when Blau gas is employed for welding or soldering without admixture of compressed oxygen. When the apparatus previously described, containing a larger gas tank and regulator, is available, the welding burner can be connected with this and the second gas cylinder will not be required. In addition to welding and soldering, for which purpose especially the facility of transporting Blau gas is often of great importance, the gas may be used as fuel in tempering metals, glass blowing, and numerous other industries. In all these cases the high pressure of the gas is advantageous, as it makes possible the production of very high temperatures without the use of a blowpipe.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

THE THOUSANDTH PART OF A SECOND.

IN a lecture delivered before the Urania Club in Berlin, and published as a summary in the Illustrirte Zeitung, Dr. Spiess made the thousandth part of a second his theme. Such a part of a second is an interval that is hardly perceptible by the human senses, and yet in physics and mechanics appear occurrences that can be measured by a very much smaller interval. The "moment" with which we designate a marvelously brief duration is a long interval when compared with the thousandth part of a second, for the human eye needs a little time to become ready for vision. A flash of magnesium passes much more quickly than the pupil of the eye is able to contract itself; with a flash of magnesium the human eye can be photographed while it is wide open, just as it always is in the dark. A flash of magnesium produces in our eye a gleam of perceptible duration, but in so doing resorts to a little deception; that is, the gleam acts on the tissue of the skin for some time after it has expired. Consequently we feel a flash of magnesium much longer than it really lasts.

Far more quickly than the flash of magnesium does the gleam of the electric spark pass; it lasts perhaps the one-hundred-thousandth part (1/100000) of a second. A white line on a black disk that is turning with the greatest rapidity cannot be seen while a flash of magnesium lasts, but can be seen easily enough under the electric gleam.

Electricity has also made it possible for us to measure the speed of flying projectiles. The doctor explained the various apparatus that are used to measure such small and the smallest intervals of time, the millisecond watch of Engineer Lipp, for instance. This watch is also used to indicate "exact time" which, as is well known, is of such great importance to the astronomer when he desires to state precisely the moment of the transit of a star in the telescope. Between looking at and pressing the button on a watch that shall indicate the moment of seeing time must be lost. Then the lecturer showed by illustration how much time one needs to respond with a movement to an excitation of the sense of hearing. The human nervous system works somewhat methodically, but still with great quickness. What happens from the time a sound is heard to the time when the perception of the sound indicates itself through physical movement, is very complicated. The sound waves—produced by a blow which, by means of an electric current, sets the index of the millisecond watch in motion—must first put in motion the tympanum and thereby the whole mechanism of the organ of hearing and its adjuncts before sound can act on the nerves of hearing; this sound leads aural sensibility to the brain where it is changed into an incitation to movement which is communicated by current to the muscles of the fingers. These must contract themselves before they can close a contact that stops the index of the millisecond watch. And yet all this has taken place in a few hundredths of a second, and can take place in exceptionally fine natures in the thousandth part of a second.

Incidentally the demonstrator made use of the chronoscope in the measurement of wonderfully short intervals. He measured, for instance, with the Boulenge apparatus the velocity of a Tesching bullet. A long and short bar of iron respectively hang from an electromagnet; the bullet interrupts at the mouth of the rifle and at the goal the current; the electromagnets lose thereby their strength and let the bars fall; a knife indents the longer bar and thus shows, in accordance with the law of gravity, how much later the longer one fell than the shorter one. In this demonstration the Tesching bullet acquired an initial velocity of 225 meters a second. Such tests must, of course, have great importance for ballistics. And by means of the Pouillet mirror apparatus the lecturer even succeeded in measuring the velocity of the projectile while it was still in the barrel of the rifle.

ANIMAL FILTERS AND STRAINERS.

THE MECHANICAL EQUIVALENTS OF NATURE.

BY DR. ENOCH ZANDER.

THE gills of fishes that live in turbid waters and burrow in the mud are always bright red and quite clean. This fact is not explained by the gill covers, for the muddy water flows continually through the gills in the process of respiration. The throats of fishes contain filters, through which the water passes before it reaches the gills. Similar filters and strainers are found in many other animals. Little attention has been given to these organs, although they are of vital importance. They may be classified as protective filters, food filters, and filters which act in both of these, and possibly other, capacities.

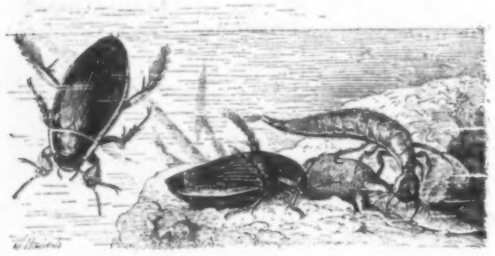


FIG. 1.—YELLOW-FRINGED BEETLES.

Male in the act of respiration, female and larva feeding on a dead tadpole.

Protective filters are found in both land and water animals. Their function is to protect the organs of respiration and other sensitive parts from defilement and injury. The breathing pores ranged along the sides of insects are provided with manifold devices which prevent the entrance of dust into the fine air passages which ramify throughout the body. The dust which is thus taken from the current of inspiration is blown away by the following current of expiration. In the yellow-fringed beetle (Fig. 1) each of the large oval breathing pores is guarded by an interlacing mass of branched, tree-like hairs (Fig. 2).

The gills of the fresh-water crab are primarily protected by long curling hair which grows among them (Fig. 3).

The aquatic larva of the caddis fly surrounds itself with a tubular case composed of stones, leaves, and other objects, fastened together with silk (Fig. 4). Before pupation the ends of the tube are closed with filters which allow water to pass through the gills of the pupa, but exclude dirt and enemies. These filters are made of silk threads in various ways (Fig. 5). Some are close tissues with a few small holes (b_1), some are very open (b_2) and some contain bits of stone (a).

The water vascular system of star fishes and sea urchins is protected by the fine branching canals of the "madrepore plate" (Fig. 6).

The most striking examples of food strainers are exhibited by the whalebone whales, which feed almost entirely upon very small animals which they strain from the water by means of the combs of whalebone with which their mouths are furnished, in lieu of teeth. These plates of whalebone hang from the upper jaw in parallel rows. The Greenland whale has from 300 to 360 such plates, the largest of which are 16 feet long and 12 inches thick at the root, and often weigh, in the aggregate, more than 3,500 pounds.

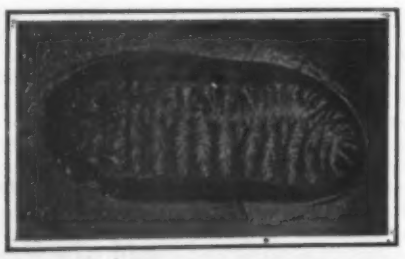


FIG. 2.—BREATHING PORE OF YELLOW-FRINGED BEETLE. (MAGNIFIED.)

The inner surfaces of the plates bear long hairs which are matted together (Figs. 7 and 8). When the jaws close, the plates and the tongue combine to form a barrier in front, so that the water with which the mouth has been filled can escape only through the whalebone strainer, which retains the slugs and other creatures that constitute the whale's food.

The spoonbill duck (Fig. 9) feeds in a very similar manner. Its upper bill forms an arch over the lower bill and bears on each side a row of smooth, horny plates (*L*, Fig. 10). Each side of the narrow lower bill is furnished with some 200 similar plates with fringed edges and of various lengths, up to 2½ inches. The capacious maw is filled with water swarming with tiny aquatic animals. When the head is raised, with the mouth closed, the water trickles

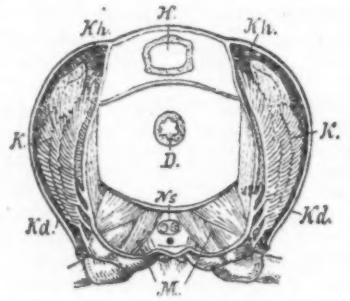


FIG. 3.—TRANSVERSE SECTION OF FRESH-WATER CRAB.

H, heart; *D*, intestine; *K*, gills; *Ns*, nerve trunks.

out at the sides between the interlocking plates, which the prey cannot pass. The whole operation is performed so quickly that the eye can hardly follow it.

Very peculiar filtering devices are found in the stomach of the fresh-water crab. The intestines of this crustacean, with the exception of a short section contiguous to the stomach, are quite useless for digestion, as they are lined with chitin, the same horny substance which forms the shell. As the short upper intestine is inadequate to the proper performance of digestion, the digesting surface has been increased

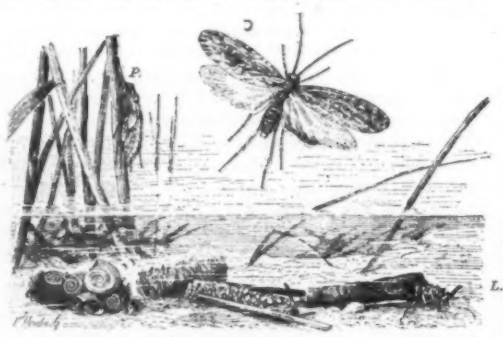


FIG. 4.—THE METAMORPHOSIS OF A CADDIS FLY.

L, larva; *P*, pupa which has left its case. In the foreground three abandoned cases composed of stones, leaves and snail shells.

in a very unusual manner. On each side of the upper intestine and communicating with it is a large yellow organ filled with countless fine tubes (*L*, Fig. 11, *b*), which is commonly, but erroneously, called a liver. The food, prepared and emulsified in the stomach, passes through these tubes which offer a very extensive absorbing surface. The tubes are so narrow that only very finely divided solid matter can pass through them. Hence, in the stomach, the food is not only thoroughly comminuted but is passed repeatedly through fine filters or strainers. The stomach is

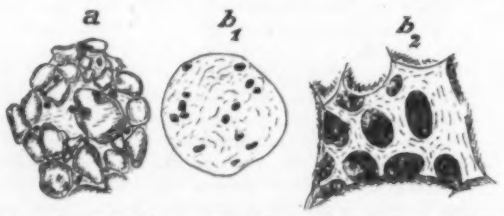


FIG. 5.—FILTERS OF THE CASES OF CADDIS PUPÆ.

divided into two compartments: a gizzard (*C*, Fig. 11) in which the food is ground, and a filter chamber (*P*), which contains a reservoir (*St*, Fig. 12) and three filters (*Mf*, *Drf*). The finely-ground food accumulates in the reservoir which, when full, is compressed by the contraction of the surrounding muscles. The pressure forces the liquid portion through three orifices fringed with hairs, which retain the coarser solid matter in the reservoir, whence it is discharged into the lower intestine. These orifices open into three filters, of which two (*Drf*, Fig. 12) are tubular in form and paved with numerous transverse ridges, the edges of which are covered with fine hairs, directed toward the reservoir, or against the current. As the liquid food flows over these ridges all coarse particles are caught by the hairs while the purified solution, or emulsion, trickles between the ridges and so finds its way to the so-called "livers." The particles removed by the filter are returned to the reservoir. The upper filter (*Mf*) is lined with hair, but not corrugated, and empties into the upper intestine.

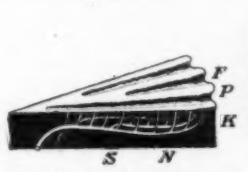


FIG. 6.—PART OF THE FILTER PLATE OF A STARFISH.

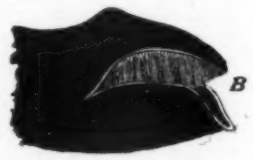


FIG. 7.—HEAD OF WHALEBONE WHALE.

In many aquatic animals the same filter serves to protect the organs of respiration and to separate the food. The animals and other solid matter taken into the mouth with the water of respiration must be removed, in order both to protect the gills and to provide food. One function or the other predominates according to the mode of life. Fishes and the larvæ of frogs and salamanders possess filters of marvelous complexity, situated in the throat, on the inner edges of the passages which lead to the gills. In the salamander larva these filters are comparatively simple, consisting only of a few small prominences, but the gill filters of the frog larva are much finer and more complex. The salamander, even in the larval state, is a beast of prey, and swallows its food in large pieces which can easily be kept out of the gills. The frog larva, on the other hand, lives chiefly on algæ, and all its food enters the throat in a finely-divided state. Hence its gills are protected by a labyrinth of projections and passages (Fig. 13) through which only water can pass.

The gill filters of fishes exhibit equally great diversity. In the simplest form the lips of the gill orifices in the throat are merely serrated, and interlock like the fingers of the clasped hands (Fig. 14). More elaborate forms, resembling combs and gratings, are shown in Fig. 15. Salmon, sole, and herring possess filters of this type. In fishes that live in clean water the closeness of the filter is dependent on the size of the animals used as food. This law is well illustrated by the salmon and herring families. Salmon, trout and other predatory species which devour comparatively large prey have coarse filters with few and small projections, while species like the herring, which feed upon very small aquatic animals, have very close and intricate filters. All fishes which, like the carp, seek their food in muddy waters, pos-

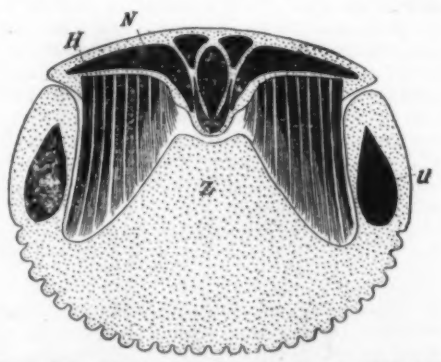


FIG. 8.—TRANSVERSE SECTION OF WHALE'S MOUTH.

H, whalebone plates; *Z*, tongue.

sess very close filters, irrespective of the size of their prey, because in this case the chief function of the filter is to protect the gills from contamination.

The tunicates or ascidian mollusks (sea squirts) possess very elaborate filters. These strange creatures, in their larval form, are as active as tadpoles, which they closely resemble, but they pass their adult existence fixed to the sea bottom by stalks. The body is covered with a leathery integument, the man-

tle or "test," which has two orifices at the free or upper end. A current of water continually flows in at one of these openings and out at the other. The inlet opens directly into a chamber known as the gill-intestine cavity. The walls of this chamber communicate by numerous fine pores with the general cavity of the body which, in turn, communicates with the outlet orifice. The wall of the gill-intestine cavity is traversed by numerous small blood vessels, the blood in which is aerated by the air dissolved in the water which flows through the pores. But the porous, sieve-like wall also serves to retain within the cavity,

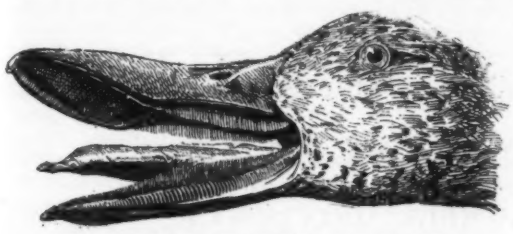


FIG. 9.—HEAD OF SPOONBILL DUCK.

at the bottom of which the true mouth opens into the stomach, all animals and other solids that the current of water brings with it. The pores are of diverse forms and are arranged in a great variety of intricate patterns, a few of which are shown, greatly magnified, in Fig. 16. They are always of microscopic size, their greatest dimension never exceeding a few hundredths of an inch, and their number is sometimes as great as 250,000.

Very similar conditions of respiration and digestion are found in bivalve mollusks. The gills, which contain nearly 8,000 pores in each square inch of their area, act as filters and collect the solids which, according to their character, are conveyed to the mouth as food or expelled as refuse.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Aus der Natur.

NATURE'S TRAPS.*

By CHARLES F. HOLDER.

THERE is a small army of hunters in this country of whose success the average citizen hears but little. They hunt with pick, hammer, and shovel and bring down game a million or a dozen million years old. A modern goose or tiger interests him not at all, but a goose a million years old will lure him on from one region to another in a quest filled with hardships, whose results are seen in all the great museums, in the restorations of the giants which lived in ancient days.

These hunters of bones become remarkably expert by studying nature, and among other things they rely upon certain curious traps which have entombed animals untold thousands of years ago. They are of many kinds, but, as a rule, they are marshes or bogs, quicksands and lakes, or pits of liquid or semi-liquid asphaltum. If a bone hunter can locate one of these he is sure to be repaid by finding a golgotha. In fact, ancient quicksands are the most common, but not always easy to find, as who would think of looking for one on the face of a cliff forty or fifty feet above a river? Yet I have seen such a one not far from the little town of El Toro, Cal. Here a little river or creek still runs into the sea, and in the thousands of years of its existence it has cut down ten or twenty feet, or more, into the soil and flowed on quietly with no suggestion of a trap to deer or any animal that might stand in its waters to drink.

In the great asphaltum lake of Trinidad is one of the most remarkable traps in the world, containing in

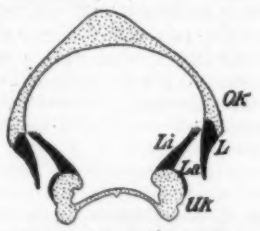


FIG. 10.—HEAD OF SPOONBILL DUCK.

L, *Li*, filter plates.

its black heart the remains of countless animals which in various ages have been caught in its treacherous folds. While it is difficult to conceive a lake of asphaltum or tar, this is a lake in every sense of the term. It covers over one hundred acres, and it is really one of the wonders of the world. Its surface is as black as ink, broken with pools of inky looking material formed of soft bitumen, with here and there bubbling spots or craters and cracks from which issues a disagreeable odor of sulphureted hydrogen. It is altogether an unpleasant sight, and almost seems to have a life of its own, as no matter how much may be taken it oozes up again and the surface is again smooth. Small birds and insects, and even herons, are to-day caught in the openings, fall and become absorbed by the black mass. In its depths, where sections have been removed, the remains of countless skeletons have been found, telling the story of the trap that for ages has been storing away its victims, holding them down in its oily depths.

There are a number of such traps in the United States. An interesting one has been known for fifty years in southern California. It is a small lake or deposit of liquid asphaltum, midway between the city of Los Angeles and the ocean, in the shadow of the Sierra Santa Monica range. There is every evidence of great age to the lake. I saw this lake first in 1886. It was from a distance an innocent pool, and about it were white herons and curlews. The old ranchers considered it a dangerous trap for their cattle, and it was said various animals had been lost in its depths. At that time the great oil industry of Los Angeles had not been started, and the deposit of tar and asphalt did not attract much attention, as it was known that there were other similar ones in southern California —one in Ventura, another north of Santa Barbara, and one out at sea, from which oil oozes up, so that a great patch of water is always smooth. Off the port of Redondo there is an asphalt spring, and the beach is often littered with tar that is washed ashore. Such quantities are found at times alongshore that the rocks are splashed with it, and large turtles caught sometimes have their mouths full of it.

The Los Angeles "trap" is found near the electric line between the towns of Sawtelle and Hollywood, in sight of the ocean. Without doubt it is one of the most valuable traps to science in the country, as possibly for a million years it has been in active operation, changing year after year in density, according to the heat, the slimy, sticky mass bubbling up

FIG. 11.—DIGESTIVE ORGANS OF FRESH WATER CRAB.

a, side view; *b*, view from above.

to entomb and trap various animals. The asphalt in some places appears to be made up almost entirely of bones that have been accumulating for ages, and paleontologists have found that many of them relate to a past age. The quarry has been excavated in places to a depth of twenty feet, and doubtless bones and perfect skeletons might be found at greater depths.

This innocent pool has lured animals into its oozy depths for countless ages; ducks, geese, herons, cranes, shore birds of every kind, insects—all the small animals of the section that would go down to a pool to drink have been caught and trapped. Coyotes, wild cats, bear, wolf, badgers, weasels, go-

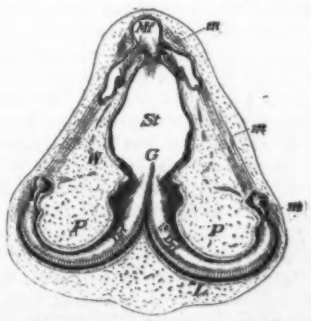


FIG. 12.—RESERVOIR AND FILTERS IN STOMACH OF FRESH-WATER CRAB.

phers, civet cats, skunks, cöons—all have been caught here. Then we enter the past ages, as here is the skeleton of the big saber-toothed tiger, a contemporary of the mastodon and mammoth, evidences of both of which have been found here. In 1887 I saw the blackened tooth of a mastodon, said to have been taken here. From the number of excellent skeletons of the saber-toothed tiger it is evident that at one time the animal was very common in southern California. The animal was, if anything, larger than the Indian tiger, and had tusks of extraordinary nature, virtual poignards with which the animal struck terrific downward blows, stabbing the enemy.

As numbers of extinct horses have been found in this trap, especially colts, it is easy to imagine that they may have been followed by the saber-toothed tiger. Here have been discovered the remains of an early bison, antelope, elk, and deer, as well as a camel —animals which were chased into the deposit by the big tigers and wolves of the period; in fact one of the common victims of this trap, that is still set for the unwary, is the big wolf that doubtless ran about the trap and was entombed in an attempt to reach other victims. The most interesting remains found

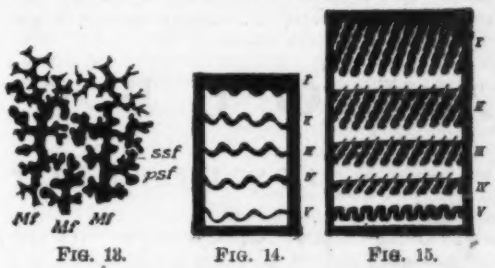


FIG. 13. FIG. 14. FIG. 15.

FIG. 13.—GILL FILTERS OF TADPOLE. FIG. 14.—GILL OPENINGS OF FISH. FIG. 15.—GILL FILTERS OF FISH.

here are those of a sloth, which may have been larger than a bison. Its claws were found, and over the bones of a skeleton were discovered the pebble-like bones of the skin.

How long this trap has been in operation no one can say, but it doubtless dates back to early Cenozoic time, which is supposed to represent about 3,000,000 years, and complete excavations may result in the discovery of all the strange animals of the Quaternary period. The animals which wandered around this trap represented a strong diversity from those of to-day. They were giants, and among them were several elephants, a huge mastodon, several horses much larger than the present horse, a giant ox, bison, a monster tapir, bears many times larger than those still found in Texas or New Mexico, a species of wild hog, and the giant sloths—megatherium, mylodon and megalonyx—ground sloths of vast size, the megatherium being eighteen feet in length; an animal that must have weighed many tons and which easily pulled large trees to the ground.

A NOVEL PROCESS FOR SOFTENING WATER.

A WATER-SOFTENING process recently invented by Dr. Robert Gans, of Pankow, near Berlin, is based on the property possessed by artificial zeoliths (permutites, basic aluminate-silicates) of exchanging their basic compounds for other bases. The new basic aluminate-silicate compounds, produced by this exchange, can be reconverted to the original compound, thus serving for another exchange. This alternate exchange and regeneration can be repeated over again without any prejudice to the reacting possibilities of the permutites.

The most suitable compound used for the softening of water is sodium permutite, which exchanges its sodium in equivalent amounts for the calcium or magnesium contained in the water, while converting itself into calcium or magnesium permutite and yielding up to the water the soluble compounds (so-

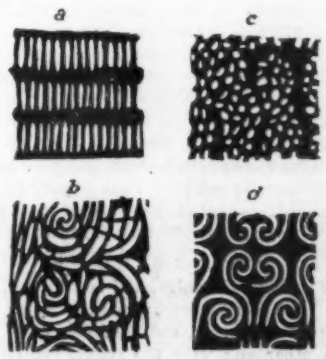


FIG. 16.—GILL FILTERS OF TUNICATES. (GREATLY MAGNIFIED.)

dium bicarbonate, sodium sulphate) produced by the reaction.

As soon as this exchange has been completed or has reached an admissible limit (which is recognized by determining the degree of hardness by means of a standardized soap solution) the permutite is regenerated by a hot solution of common salt allowed to flow through the permutite layer at a moderate speed. Common salt denaturated by charcoal (in quantities three to four times the amount of bound lime) is used for regenerating the substances used in the process.

The filtering speed should be adapted to the hardness of the water and the output desired.

* From American Homes and Gardens. Published by Munn & Co.

The apparatus used in connection with this process is an iron or wooden filter of cylindrical shape, terminating in a cone at the bottom. The height of the permutite layer should bear an empirical ratio to the hardness of the water as well as the rate of filtration. A high permutite layer generally assures a better exchange than the same amount of permutite when arranged in a broad stratum. The conical part of the filter is interrupted at its center by a horizontal perforated sieve, carrying a layer of coarse gravel, and on the top of this, a layer of fine gravel, serving as a support for the permutite. The permutite layer, with a view to retaining the fine permutite particles, is covered on the top with a loose though dense stratum of finely spun wood-wool, kept back immediately below the discharge tube by a perforated cover coated with linen.

As the regeneration process only consumes six hours, an installation comprising a single filter will be sufficient in many cases; should this not be the case, it would be advisable to place at its side another filter to be operated during the time the first filter is regenerated.

A reservoir into which is pumped the regenerating solution of common salt (15 to 20 per cent), prepared in a pot or vat and filtered through bags, is arranged on the top of the filtering plant. The permutite is not used up to any material degree.

The main advantages of this process are the simplicity of apparatus and ease of manipulation, a stoker being able to superintend its operation besides his ordinary work. By controlling the speed of filtering, the water to be softened is raised to any admissible limit of hardness. There is no subsequent reaction as in the case of the lime-soda process nor are the men inconvenienced in any way (by lime dust, etc.). There is no necessity of carrying away the slime, nor is there any injurious formation of boiler scale.

ALGEBRAIC SYMBOLISM.*

ITS DEVELOPMENT FROM PACIUOLO TO NEWTON.

BY SUSAN R. BENEDICT, TEACHERS COLLEGE, COLUMBIA UNIVERSITY.

THE growth of the symbolism of elementary algebra from its first appearance in print at the end of the fifteenth century to the time of Newton when it was practically complete, roughly divides itself into two periods, each about a century in length. There were in the sixteenth century two general methods of writing algebraic symbols, the one in use in Italy and Spain, and the other in the northern countries. Of these two systems the Italian is the older and therefore should have first attention.

The earliest printed work on algebra is contained in a volume published in Venice in 1494. It was written by a Franciscan monk who, after a youth of travel and adventure, retired to a monastery and there made for himself an honorable name through his works. This man was Luca Paciuolo, commonly known from his birthplace as Fra Luca di Borgo San Sepulcro, and his great work was entitled, "Summa de Arithmetica, Geometria, Proportione et Proportionalita." The book is merely a compilation made by a man with the interests of a teacher; and what has been said of his methods, that he gave little that was new, is also true of his symbols, many of which are found in the fifteenth century manuscripts.[1] But just as his summary of methods is valuable, so his table of "Caratteri Alghibratici," the earliest in which they are systematically explained, is of great historic interest. The first character used is a radical sign, simply an abbreviation of the word *radix* or *radice*, signifying root. The symbol is Ʀ and it is usually followed by abbreviations of the words *prima*, *secunda*, etc.; the first two and the last of the thirty roots being written as follows: Ʀ.p^a., Ʀ.2^a., Ʀ.30^a. Besides using these forms, the second, third, and fourth roots are frequently written Ʀ., Ʀ.*cu.*, and Ʀ. Ʀ. and there is still another symbol, Ʀ.*v.*, which Paciuolo calls *Radice Universale* and uses to indicate the root of a polynomial.

Among Italian writers of this period it was very common to indicate the omission of one or more letters by a line drawn above. So we find in the "Summa" the words for plus and minus, in Italian *più* and *meno*., indicated by $\tilde{p}$ and $\tilde{m}$. In common with many of the early algebraists Paciuolo calls the absolute number *numero* and symbolizes it .*n°*. The unknown quantity was *thing*, in the Italian *cosa*, and from this word were derived the names *Coss* and *Cossic Art*, which at the opening of the Renaissance were synonymous with algebra. The name for the square was *censo*. Cossali, in his "Origine dell' Algebra,"[2] says that the word is probably of Latin derivation and was adopted by Leonardo of Pisa, but that its original meaning is unknown. *Cubo*, for the cube, needs no explanation, and for *relato*, a term signifying a power whose exponent is not a multiple of two or three, there seems to be none. The symbols used are abbreviations of the names: .*co.* for the first power, .*ce.* for the second, .*cu.* for the third, and $.\overset{\circ}{p}.\overset{\circ}{r}.$, $.\overset{\circ}{2}.\overset{\circ}{r}.$, etc., for the *relati*. All other powers are built up by a multiplicative plan through a combination of .*ce.* and .*cu.* with each other and with the *relati*, but it must be noticed that two *relati* are never written together; for example, the twenty-fifth power is not $.\overset{\circ}{p}.\overset{\circ}{r}.\overset{\circ}{p}.\overset{\circ}{r}.$ as we might expect, but $.8.\overset{\circ}{r}.$[3]

Another great name, in connection with the Italian symbolism, is that of Tartaglia, to whom we owe the first solution of the cubic equation. In his "General Trattato" (Venice, 1556) he uses most of Paciuolo's symbols, but, since the first power and the first root are the same, he discards .*co.* and uses Ʀ *prima* in its place. In this work, then, we find the powers of the unknown written as follows: Ʀ *prima*, *ce*, *cu*, *ce.ce*, *rel*, *ce.cu*, $\frac{3}{4}$ *rel.*, etc.[4] The roots are indicated by Ʀ followed by *ce* or *cu*, as the case may be, and the universal radical appears as Ʀ.V. For *plus* Tartaglia writes the word *piu*, or more frequently the letter *p*, the upper part of which is nearly surrounded by a curved line, and his minus may be *men*, *me*, or $\tilde{m}$. But the most interesting bit of symbolism in the "Trattato" is the trace of the parenthesis in the expression 22 *men* (22 *men* Ʀ 6.) which is given as the product of

$$\sqrt{22}+\sqrt{22-\sqrt{6}} \text{ and } \sqrt{22}-\sqrt{22-\sqrt{6}}.$$[5]

The arithmetic of Antich Rocha (Barcelona, 1565), in which we find one of the earliest chapters on algebra written in the Spanish language, also uses the Italian symbols, although they are modified even more than in the "Trattato." The radical sign does not appear, but the symbols for the powers of the unknown quantities, including the zero power or the absolute number, are as follows: *N*, *Co*, *Ce*, *Cu*, *Cce*, *R*, *CeCu*, *RR*, *Ccce*, *Ccu*, *Rce*, etc.[6] For the plus sign Rocha uses word *mas* or its abbreviation *ma*, and for the minus sign *me*, an abbreviation of *ménos*.

These three writers are by no means the only ones to use the Italian symbols. Many others, among them Cardan,[7] use all or part of them, but the books which have been mentioned may well be taken as types of the others. This symbolism was, however, restricted almost wholly to the south, and in the meantime there was growing up in the north a system which became far more popular. This is described in Stifel's edition of Rudolff's Coss (Nürnberg, 1553) and in Robert Recorde's "Whetstone of Witte" (London, 1557).

In Stifel's work the absolute number is called *dragma*, indicated by a modified *d*, and the unknown is *radix* whose symbol has never been explained.[8] There are, however, in Paciuolo's "Summa" several cases in which the radix is written with a small r^a. Reasoning from this fact and remembering that radix often means the unknown quantity as well as the root, it seems very possible that manuscript writers might easily have changed that symbol to the one in question. *Census* of the Italians is *zensus* with the Germans, and the symbol 3 is merely the initial letter. For the cube we find a sign which again is evidently developed from the Italian symbol, for in manuscripts the letters of *cu* are frequently joined at the top, from which the evolution of the German form is an easy matter. Instead of *relato*, the Germans used *sursolidus*, from whose symbol, together with those for *zensus* and *cubus*, all the other powers are formed by a multiplicative plan. The + and — are seen here as signs of operation, and indeed Stifel is generally considered to have been the first to use them as such. He is not entitled to this credit, however, for they appeared "in a work by Grammeteus in 1514,"[9] and again in 1537" in a remarkable little book published in Antwerp by one Gillis vander Hoecke.[10] Stifel's radical sign is nearly like our own, appearing as √ followed by the symbol to show the index, and, in the case of the universal radical, separated from the quantity to which it refers by a large dot. But these were not the earliest forms, as appears from Stifel's commentary on Rudolff, who he says used a sign with three angles for the cube root and two for the fourth.[11] Recorde's "Whetstone of Witte," which was the first algebra printed in English, and Masterson's "Arithmeticke" which followed it,[12] represent the powers of the unknown by symbols which differ from Stifel's only in that they are printed with much bolder type, and that *sursolidus* has a slightly different form. Masterson's radicals are also the same as Stifel's, but Recorde follows the plan of Rudolff. There was, nevertheless, one important contribution made by Recorde, namely, the equality sign, which he says is "a paire of parallels or *Gemowe* lines of one length, thus ═ because noe. 2. thynges can be moare equalle."[13]

The first French work on algebra, that of Jacques Peletier, Paris, 1560), combines the Italian and the German symbolism. Here we find the German symbols for the cube, the fifth power, and the radical sign, but for the first power Ʀ is used, while the square is *q*, and the plus and minus signs appear $\tilde{p}$ and $\tilde{m}$.

One of the most important writers to use the German symbols was the Jesuit Christopher Clavius, whom we ordinarily think of as belonging to the Italian school, since he lived and taught in Rome. He was a native of Bamberg, however, and his German origin is very evident in his "Algebra" (Rome, 1608). Clavius uses Stifel's system in its entirety except that *N* stands for the absolute number, and the parenthesis is used to show the universal radical. Such an expression as $\sqrt{3}(15+\sqrt{3}144)$[15] occurs very often, a form which was probably suggested to him by Bombelli's "Algebra."

Although during the sixteenth century most of the writers were using one or the other of these systems, or a combination of both, there were a few by whom its limitations were felt, and whose efforts at improvement are noteworthy. The first of these is Cardan, a man whose powerful intellect was felt in every phase of life. In his earlier work he adopted the Italian symbols, but in his masterpiece, the "Ars Magna" (Nürnberg, 1545), they are much less used. Ʀ appears as the sign for the root, and *plus* and *minus* are still indicated by *p* and *m* although without the line above, and always separated from the term to which they refer by a colon. *Primo relato* is also used for the fifth power, but the symbol $R^{\circ}p^{\circ}$ differs from the one in common use. Here the similarity to the old method disappears, for the other powers of the unknown are indicated by the Latin words *res* or *positiones*, *quadratus*, and *cubus*, which Cardan writes in full or abbreviates to suit the context, using the proper terminations to designate the Latin case. Thus, for example, the first power is sometimes *pot*[14] and sometimes *reb*,[15] and the square may be $\tilde{q}d^4$, qd^2, or any one of a variety of other forms. Cardan used a multiplicative plan of combination, and his symbols are even more unsatisfactory than those he discards; but nevertheless the change is an evidence of his dissatisfaction with those in existence.

In this connection, there are two men whose work is most important, namely, Raphael Bombelli of Bologna, and the Hollander Simon Stevin, both of whom used a method approaching the exponential system. Bombelli's "Algebra" was published in two editions, in 1572 and in 1579, which is evidence of its worth and appreciation. Here the powers of the unknown are expressed by the figures 1, 2, 3, etc., written above small arcs[16], and it is evident that Bombelli had some idea of the significance of the exponent, for he explains at considerable length that the product of $3^{\frac{1}{2}}$ and $10^{\frac{1}{3}}$ is $30^{\frac{5}{6}}$, because "the whole sum of 1 and 1 is 2."[17] These symbols, when used in the text, follow the coefficients, but in adding or subtracting polynomials

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* School Science and Mathematics.

[1] Several of these manuscripts have been examined in the preparation of this report, but no reference is made to them for the reason that they antedate Paciuolo.

[2] Vol. I, p. 12.

[3] For Paciuolo's symbolism, see Summa, f. 67, v.

[4] Trattato, Vol. II, f. 39, r.

[5] Trattato, Vol. II, f. 169, r.

[6] Arithmetica, f. 253.

[7] Practica Arithmetica, Milan, 1537.

[8] For Stifel's symbolism, see the table at the end of this report.

[9] Summa, f. 128, v.

[10] The page from Grammateus is reproduced in Prof. Smith's Rara Arithmetica, Boston, 1908, p. 125.

[11] The page from vander Hoecke is also reproduced in the same work, p. 185. The student may thus consult the fac similes of the original sources.

[12] Stifel's Rudolff's Coss, f. 82, v.

[13] London, 1592-94.

[14] Whetstone of Witte, f. Ff, j, v.

[15] Algebra, p. 90.

[16] For Bombelli's symbolism, see the table at the end of this report.

[17] Algebra, p. 205.

they are often written above, thus furnishing an early example of detached coefficients. Bombelli's radical sign is simply an *R*, followed by *q* or *c*, to show the index, but in connection with this sign there is one very interesting point to be noticed, namely, the use of the adjective *legato* and its initial letter *L*. The word was not original with him, for we find it in Cardan's arithmetic[18] where it signifies that the radical sign is to apply only to the term immediately following; for example *L* R̃ 3 *p* : R̃ 8 would mean $\sqrt{3} + \sqrt{8}$. Bombelli adopts the name and the symbol, but in his work, *legato* is synonymous with *universale*. Here we find the *L* written after the *R* and the expression is completed by placing an inverted *L* at the end[19] as in *R.q L* 128. p. 8^2 ⌋. The Italian word *legato* means bound, or fastened together, and it is quite possible that our signs of aggregation may have had their origin in the initial letter *L*. In that case the idea of the bracket would not be due to Girard (1629), as the historians assert, but to Bombelli in 1572.

Almost contemporary with Bombelli, there lived in Holland another mathematician, Simon Stevin, who was working along the same line. Stevin was one of the best thinkers of his time and is well known as being among the first to use the decimal fraction. His symbols for the powers of the unknown are the same that he uses to indicate units, tenths, hundredths, and so on, in decimal fractions, namely, small figures placed in circles.[20] If Stevin finds that several unknowns are necessary, he forms them by prefixing *sec* or *ter* to the appropriate symbol and often combines these in the same term. In this combination we often find an *M* used to denote multiplication, and there is a corresponding use of *D* for division which is common but by no means universal with Stevin. The radical sign appears in the German form, √ representing the square root, and the fourth and eighth roots requiring only the addition of a second and third angle. The symbol for cube root is the sign √ followed by the 3 in a circle,[21] which is modified by another angle to form the ninth root. These signs when placed before a monomial affect all of its factors unless they are separated from one another by a double arc forming a symbol which resembles an X, in which case the radical affects only the part preceding the sign. To indicate a root of a polynomial, Stevin writes the word *bino* or *trino* after the radical sign, and we will frequently find such expressions as √ *bino* 2 + √ 3 or √ *trino* √ 3 + √ 2 — √ 5 for $\sqrt{2 + \sqrt{3}}$ and $\sqrt{\sqrt{3} + \sqrt{2} - \sqrt{5}}$.

None of the early attempts to form a symbolism was really successful, and the first noteworthy improvement was made toward the close of the sixteenth century. This was accomplished by François Vieta, the greatest French mathematician of his generation, in whose mind was conceived the idea of a general symbolism by which known as well as unknown numbers might be represented. He wrote at different times during the last quarter of a century and much of his work has been lost; but from what was recovered and edited by Franciscus Van Schooten in 1646, a fair idea of his symbolism can be formed. In the theoretical part of his work the unknowns are expressed by the capital vowels and the known quantities by the consonants. To raise these to any power, the words *quadratus, cubus*, etc., or their abbreviations, are written after, as *A quad* 4, or *A cub* in *E plano* 2, for $4x^2$ and $2x^2y$. One of the treatises saved by Van Schooten is called "De Aequationum recognitione et emendatione," and was first published after Vieta's death by his friend Alexander Anderson. In this paper appears still another symbolism which may or may not have been due to Vieta.[22] Here a fair beginning is made in the theory of equations and the statements are made in a symbolism which is generally known as Vieta's. But below each theoretical statement there appears in smaller type a numerical equation as an illustration, with a symbolism altogether different. The unknown number is represented by *N*, the square by *Q*, and the cube by *C*, and these are combined by an additive plan to form the higher powers. For example, Vieta says, "*If Acubus—B—D—G in Aquad+B in D + B in G + D in G in A* equals *B in D in G*, then *N* is either *B, D or G*," and below it, by way of explanation, "If 1*C*—6*Q*+11*N* equals 6, then *N* is either 1, 2, or 3."[23] Another noteworthy feature is the vinculum, which was first used as a sign of aggregation in this work, and the symbol ═══, by which Vieta indicates the absolute difference.

These symbols of Vieta were used for many years although they underwent several modifications, notably in the work of Harriot.[24] In this work the *A* was changed to *a*, and the powers were formed by a repetition of the letter, as in *aaa* for our x^3. Here also the equality sign is more commonly used than in any earlier algebra, and the signs < and > first appear to express inequality.[25] Harriott also uses a double bar in writing complex fractions, as in the case of

$$b = \frac{aaa}{bd}, \text{ a symbolism not accepted by his successors.}$$
$$d$$

Harriot's symbolism was not a bad one and might have remained in use until the present time had there not appeared, in the person of Descartes, a man whose authority was universally felt. In writing "La Géométrie" (Paris, 1637), Descartes felt it better to discard most of the symbols then in use and to adopt for knowns and unknowns, respectively, the first and last letters of the alphabet as we use them to-day. The exponents which in this work are always positive and integral, are represented by small figures placed above and to the right, but in case of the square the letter is always repeated instead of being affected by the exponent 2. In dealing with the equation, Descartes usually transposes all the terms to the left side, marking by an asterisk the places of any powers that may be wanting, and representing the equality by the sign ∝, as in $x^5 * * * * - a^4b \propto o$.

With Descartes, therefore, our modern elementary symbolism became fairly perfected, and it needed only the authority of a Newton to make it permanent: Newton's "Arithmetica Universalis," containing his lectures on algebra at the University of Cambridge, appeared in London in 1707. In the first few pages of this work the symbolism is explained. The symbols were not original with Newton, but were essentially those of Descartes, with a few due to Harriot, Girard, and Recorde. The fact that he judged them worthy, however, and that he made use of them in one of his best known works, was sufficient to give them such standing that they are still the recognized language of algebra.

It would be easy to select from the works consulted numerous other symbols of interest which have been suggested, and which have served their purpose either for the time, or even until our own day. In Harriot's work, for example, some useful symbols of aggregation are introduced, and in Recorde's the equations are particularly interesting, but the space allowed for this report permits of reference to only a few of the more important symbols not generally studied at first hand even by certain writers on the history of the subject. It is hoped that the information given, fragmentary as it is, may be helpful to teachers of mathematics.

In conclusion, there is appended a table showing some of the symbols as they appear in the original works. The copy of Vieta consulted is in the library of Columbia University, but for an opportunity to examine the writings of the other mathematicians I am indebted to Prof. David Eugene Smith, through whose kindness the books in his own library as well as many of those belonging to George A. Plimpton, Esq., of New York, have been placed at my disposal.

Present Symbols		√	√̄	√̄	√‾	I	K	x^2	x^3	x^4	x^5	+	−	=
Paciuolo	R̃.p⁰.	R̃.2⁰.	R̃.3⁰.	R̃.4⁰.	R̃.v.	.n°.	co.	.ce	.cu.	.ce.ce.	.p.p.	.p̃.	.m̃.	
Tartaglia		R̃	R̃cu	R̃R̃	R̃V		R̃prims	ce	cu	ce.ce	rel	p̃	m̃	
Rocha						N	Co	Ce	Cu	Cce	R	ma	me	
Stifel		√	√cc	√ggg	√.	ȸ	ȸ	ȸ	ȸ	ȸȸ	ȸ	+	−	
Recorde		√	ww	w		ȸ	ȸ	ȸ	ȸ	ȸȸ	ȸ	+	−	═
Masterson		√ȝ	√ce	√ȝȝ	√ȝ.		ȸ	ȸ	ȸ	ȸȸ	ȸ	+	−	
Peletier							R̃	ȸ	ȸ	ȸȸ	ȸ	p	m	
de la Roche		R̃					ſ	ȸ	□	c ȸ	β	p̃	m̃	
Clavius		√ȝ	√cc	√ggg	√(E_)	N	ȸ	ȸ	ȸ	ȸȸ	β	+	−	
Halcke						N	ȸ	ȸ	ȸ	ȸȸ	β	+	−/+	
Ghaligai		R̃□	R̃□	R̃□□		n°	c°	□	□	□□	∃	piu	m°	
Cardan		R̃	cu R̃		R̃V:	ⅈ	res	q̃d	cub	q̃d q̃d	R̃ p̃	p:	m:	
Bombelli		R.q	R.c	R R.q	R L ⌋		ȸ	ȸ	ȸ	ȸ	ȸ	p	m	
Vander Hoecke	h	R̃²ª	R̃³ª	R̃⁴ª		n	Pri	2^A	3^A	4^A	5^A	+	−	
Stevin		√	√①	w	√bino	⑩	①	①	①	①	①	+	−	
Vieta		√	√C.	w	√‾		A	Aquad	Acubus	Aquad-quad	Aquadcub	+	=	
Harriot		√	√ȝ)				a	aa	aaa	aaaa	aaaaa	+	−	═
Descartes		√	√C.		√‾		x	xx	x^3	x^4	x^5	+	−	∞
Newton		√	√̄	√̄	√‾		x	xx	x^3	x^4	x^5	+	−	=

[18] Arithmetic, f. A. 7, v.

[19] Bombelli's Algebra, p. 356.

[20] For Stevin's symbolism, see the table at the end of this report.

[21] Œuvres, Girard edition, p. 19.

[22] For Cantor's discussion of this point see Vorlesungen über Geschichte der Mathematik, Vol. II, p. 582.

[23] Opera Mathematica, p. 158.

[24] Artis analytica, London, 1631.

[25] "Comparitionis signa in sequentibus surpanda
Æqualitatis = vt *a* = *b*. significet *a* æqualem ipsi *b*
Maioritatis > vt *a* > *b*. significet *a* maiorem quam *b*
Minoritatis < vt *a* < *b*. significet *a* minorem qaam *b*."—p. 6.

IVORY AND ITS IMITATIONS.

THE three great ivory markets of Europe are Antwerp, London and Liverpool. In 1908, 228 tons of ivory were sold in Antwerp, 214 tons in London and 28½ tons in Liverpool. Twenty years previously, in 1888, only 6 tons were sold in Antwerp, while London sold 373 tons and Liverpool 105 tons. This rapid rise of the Belgian port to the first place is due to Belgian control of the vast stores of ivory of the Congo region. The annual imports, as a rule, considerably exceed the sales. At Antwerp a stock of 270 tons has accumulated. It is a remarkable fact that France receives from her extensive African possessions little more than one-fifth of the ivory she uses, and buys the rest in England.

The fear has been expressed that ivory, like coal, will one day be exhausted. The stocks possessed by savage tribes are rapidly dwindling and elephants are yearly becoming less numerous, although the species does not appear to be doomed to speedy extinction. The increasing scarcity and cost of ivory have caused the invention of various substitutes and imitations, the production of which has already become a very important industry. In one process the chips and dust produced in working natural ivory, or even ground bones or horns, are steeped in dilute sulphuric acid at a temperature below 95 deg. F., drained, mixed with a solution of copal in alcohol and cast in molds. In another process, a solution of India rubber in chloroform is mixed with an insoluble white salt, such as zinc carbonate or calcium phosphate, and the mixture is poured into molds and subjected to pressure. The India rubber solution may be replaced by gelatine or Givet glue mixed with a solution of aluminium sulphate. Imitations of ivory are also made of celluloid with various additions. Still another good substitute is vegetable ivory, obtained from the Peruvian corozo, or ivory nut (*Phytelephas*). This substance has long been used in the manufacture of buttons.

COLORED FIREWORKS.

THE preparation must be effected with the greatest possible care, the danger of explosion not being excluded. Blue Flame.—I. 2 parts of orpiment, 3 parts charcoal, 5 parts chlorate of potash, 13 parts of sulphur, 77 parts nitrate of potash. II. 15 parts of sulphur, 15 parts sulphate of potash, 15 parts sulphate of copper ammonium, 27 parts nitrate of potash, 28 parts chlorate of potash.

White Flame.—I. 30 parts nitrate of potash, 10 parts of sulphur, 5 parts black sulphide of antimony, 3 parts flour, 2 parts of pulverized camphor. II. 1 part charcoal, 11 parts sulphur, 38 parts nitrate of potash. III. 1 part of stearine, 1 part carbonate of baryta, 4 parts of milk sugar, 4 parts nitrate of potash, 12 parts chlorate of potash. As a general thing the rule holds good that in the making of indoor fireworks, in place of the sulphur, a corresponding quantity of shellac can be used.

Smokeless Colored Fire.—First take—this is important—baryta or strontium, make them glowing hot in a suitable dish, remove them from the fire and then add the proper quantity of shellac. The latter (not pulverized) will at once melt and can then be intimately mixed, by means of a spatula, with the baryta or strontium. After it has cooled it is pulverized. Add also, possibly, about 2½ per cent of magnesium powder, to heighten the effect; for instance, if one takes 4 parts of strontium or baryta and 1 part of shellac.

Green.—5 parts shellac, 1 to 1.2 parts of sulphate of baryta are melted, after cooling pulverized and then mixed with 2 to 5 per cent of chlorate of baryta. The latter intensifies the color.

Red.—5 parts of shellac, 1 to 1.2 parts nitrate of strontium; preparation as above. In damp weather an addition of 1 to 4 per cent of chlorate of potash to the red fire may be made. The latter causes somewhat more smoke.

Both fires give off but little smoke and can be burned in a room. The smoke is not oppressive. They burn brilliantly. The charges should be in long piles.

ENGINEERING NOTES.

The making of tin-plates originated in Bohemia, according to a recent paper by Mr. William E. Gray, hammered iron plates having been coated with tin in that country some time before the year 1600. Tin-plate making was introduced in England in 1665, the art being brought there from Saxony. In France the first tin-plate factory was established in 1714. The first commercial manufacture of tin-plates in the United States was at Pittsburg, in 1872; but the industry did not develop largely until after 1890.

We quote the following from the 1907 Coal Report of the Labor Bureau of Illinois: "The number of coal-cutting machines increased from 962 to 1,105, nearly 15 per cent. The use of powder in the mines is still on the increase; this year shows that 1,261,910 kegs of 25 pounds each were consumed in blasting coal; this is an increase of 243,537 kegs, or 22.83 per cent more than was used last year. Seventy per cent of this powder is used in the sixth, seventh, eighth, ninth, and tenth districts. There were 165 men killed in the mines during the year, and 636 were more or less seriously injured. The record last year was 155 killed and 480 injured; the number injured this year is greater than for any year since 1896. The ratio of accidents for the year was 2.5 killed, 9.7 injured to each 1,000 persons employed."

Steam is being generated in all parts of the country with the coal which is mined near by or which is available at a reasonable freight rate. Some are burning coal which others would consider as impossible fuel for their plants. It is generally known that there is a difference in the character and heating value of the coal mined in the United States, and yet very few people realize how great these variations are. Much coal is left in the mines of West Virginia and Pennsylvania as being of such low grade that it will not pay to market it. This so-called low-grade coal is, however, but little less valuable than the regular output of the mines, and is in many cases much better than the best coal mined in the States farther west. Preference is naturally given to those coals which have a small percentage of ash and do not clinker badly, and to the larger sizes such as lump or egg. The Technologic Branch of the United States Geological Survey has been conducting tests on all the fuels of the country, and many valuable facts have been established regarding their character and the best methods of utilizing them.

One obstacle in the way of securing cheapness in constructing reinforced concrete buildings is the cost of the forms, which frequently cannot be used again. Mr. F. W. Dean, mill engineer and architect of Boston, has recently designed a number of buildings with brick walls and reinforced concrete floors and roofs, which remove this obstacle and overcome the objections frequently urged against the appearance of reinforced concrete buildings unless the owners are prepared to spend sufficient money to finish them in an attractive manner. Unfortunately, this is not often done in buildings of the manufacturing type. By the use of brick walls, however, it is possible to obtain the excellent appearance of brick-work, and to do so without the use of forms. In the buildings designed by Mr. Dean the concrete girders and floor slabs are connected to the brickwork without difficulty. The result is that the advantages of a reinforced concrete building are obtained at less cost and without any special knowledge of concrete for the walls. Although the excellence of concrete buildings is fully recognized, they nevertheless require a great deal of care in placing the concrete so that it touches the reinforcement everywhere and fills all the spaces.

It may not be generally known that a peat electric station has been in successful operation for over five years at Skabersjö, Sweden, and has now been working over five years. The bog which supplies the peat is only small, about 37 acres, with an average depth of five feet, and is estimated to last for a period of thirty years. There are two Korting suction-gas producers and two gas engines, with direct-coupled electric generators of 150 horse-power each. The power is conducted from Skabersjö to Svedala, a distance of two to three miles, and there some of it is used for lighting the streets, and some is distributed to mechanical works and several small industries. Although the by-products, with the exception of tar, are not recovered—the plant not being large enough to make this remunerative—the cost of production is very low. The price of power paid by the consumers is, besides a small yearly charge per motor, only 2 öre (about one farthing) per horse-power hour. A number of power stations of this kind have now been and are being erected in various parts of Sweden and other countries. For some time experiments have been made by several inventors of peat-gas producers on the recovery of by-products (especially sulphate of ammonia) and it is expected that, at a power station of a few thousand horse-power, the cost of the power will be fully covered by the sale of the by-products, i. e., we shall have power for nothing.

ELECTRICAL NOTES.

The block signaling installation now under way on the St. Louis & San Francisco Railway, states the Engineering Record, is one of the largest continuous automatic signaling systems ever put down at one time. It covers a total of 719 miles, most of which is single track, with a maximum block length of 2¼ miles on single track and 1 mile on double track. The signals are of the three-position upper-quadrant normal-clear type.

According to the Electrical Review and Western Electrician, a solar electric generator, the invention of Mr. George H. Cove, of Somerville, Mass., consists of a steel framework, which is placed where it will receive the direct rays of the sun. Short plugs of a secret metallic composition are set into this framework, which is divided into sixteen 12-inch squares, each containing 61 metallic plugs. These plugs are set with one end under glass while the sun shines on them. The other ends are exposed to the open air and sheltered from the sun's rays. The difference in temperature of the two ends of the metallic plugs generates a thermo-electric current, which is used for charging a storage battery. If the sun goes under a cloud and the voltage drops below that of the storage batteries, an automatic circuit-breaker breaks the circuit between the generator and the storage batteries. When the sun sets in the evening the circuit is automatically broken.

Bread is baked by electricity in a bakery at Kerns, Switzerland. The oven is about 8 feet long and 4 feet wide, with a heating surface of more than 30 square feet. It takes a batch of about 100 pounds of bread in two or three pound loaves, and consumes at most 18 kilowatts by means of forty-two heating tubes which traverse the bottom of the oven. The time employed for baking each batch, including charging and emptying, is about an hour and a half. In twelve hours, therefore, eight batches or about 900 pounds of bread can be baked with the consumption of 180 kilowatt hours, or 1.5 kilowatt hour per pound. As the kilowatt hour here costs only 0.7 cent, the baking costs only 0.14 cent per pound. The oven can also be operated continuously day and night with a further reduction of expense, as the oven would not have to be reheated after cooling. The bread thus baked is of excellent quality and uniformity, because of the distribution of the current through the oven in accordance with the unequal conditions of cooling, the current being gradually diminished from the front to the back of the oven.

Intercomparisons of the electrical resistance standards of the National Physical Laboratory, the Reichsanstalt, and the Bureau of Standards at Washington, give identical values for the high resistance coils, while the values assigned to the unit coils do not differ by more than one part in 100,000. Weston normal cells set up in the laboratory have been sent to Paris, Berlin, Washington, and to various laboratories in Canada, Chili, India, Japan, the Netherlands, Mexico, Russia, Spain, and Switzerland, in most cases as a result of the Conference. The agreement among these cells is extremely close. Perhaps the most interesting among them are two which were given to Prof. Tanakadate, of Japan; one of these was set up at the National Physical Laboratory, the other at the Bureau of Standards. The N. P. L. cell, K 10, was taken by Prof. Tanakadate to Washington and thence to Tokio. It then traveled back *via* Siberia to Berlin, and after an interval of eleven months was returned to Teddington. Its E. M. F. had apparently decreased by three parts in one million. The American cell reached Teddington at the same time, and when compared differed only by two parts in 100,000 from our standards.

A consular report, dealing with the trade and navigation of the consular district of Kobe, states that in the supply of electrical machinery, equipment, etc., there has been active competition between British, American, and German manufacturers. Until recently an American firm had practically a monopoly in this district, but latterly British and German firms have secured contracts. With the opening up of electric railways and the extension of various electric light companies it is probable that large quantities of electrical machinery, etc., will be required during the next few years. Generally speaking, the report states, the engines and boilers in Osaka factories are of British make. At present there is considerable demand for boilers made by a British firm which seems likely to secure a monopoly in the future. It is impossible for British manufacturers to secure contracts for machinery, etc., unless they have an experienced representative on the spot, as a knowledge of local and personal considerations and the methods of tending, etc., is absolutely essential. The import of bicycles increased from 1,901 in 1907 to 5,193 in 1908. There are a few bicycle factories in Osaka which make an inferior class of machine, importing some of the parts for the purpose.

TRADE NOTES AND FORMULÆ.

To Cement Hard Rubber to Metal.—Good, previously steeped Cologne glue is boiled down to a thickly fluid consistency and into this enough sifted wood ashes stirred to produce a homogeneous, not too thick mass, which should be used warm; a careful putting together of the pieces while drying is advisable.

Paint for the Protection from Moisture of Gable-ends on the Weather Side.—25 parts of pitch, 15 parts of rosin, 3 parts of English red, and 6 parts of brick dust are boiled in a kettle, stirring in the meantime, then one-quarter of the volume of oil of turpentine is added, so that the mixture is of the proper consistency. Apply it as thin as possible with a scrubby brush.

Hydro Sandstone is produced by making a thin mixture of fine sand with hydrate of lime powder and a certain portion of silicate. This is pressed as dry as possible into molds and after air drying for several days treated for a prolonged period in a water bath at 203 to 212 deg. F. After at most a week the artificial sandstone is finished and it not only displays outside the perfect appearance of natural sandstone, but is also so hard inside that it possesses the solidity of natural sandstone.

To Solder Glass Together.—This is effected with the aid of a metal alloy consisting of 95 parts of tin and 5 parts of zinc. The melting point of this alloy is about 425 deg. F. The glass to be soldered is first carefully heated to the above temperature and the alloy is then spread on the glass with the aid of a soldering iron and on cooling it will be firmly attached to the glass. An alloy of 90 parts of tin and 10 parts of aluminium can also be used for the same purpose, but not so conveniently, as it does not melt until it reaches 830 deg. F.

Floor Stain.—Boil 250 parts of fustic and 120 parts of Brazil wood with 2,400 parts of soap-boiler's lye and 120 parts of potash until the fluid amounts to 12,000 parts. In the decanted solution 30 parts of orleans and 750 parts of wax are allowed to dissolve, with the help of heat, stirring until cold. This furnishes 9 to 10 bottles of brownish red stain, enough to provide for a large room for a year. The floor must be swept daily with a bristle broom and twice a week wiped over with a half-moist rag, then in part where the wear from walking is greatest, painted with the stain and brushed with a stiff brush. Every four to six weeks the entire floor is to be coated with stain with the aid of a brush and immediately scrubbed.

New Sympathetic Ink.—Phenolphthalein, as is well known, produces with alkalies a most beautiful color reaction, assuming an intense red color. Writing done with a weak solution of phenolphthalein is hardly visible on the paper but appears at once if the paper be wiped over with a cotton pad wetted with soda or some other alkaline solution. No precautions are thereby necessary to prevent blurring, for the alkaline solution soaks into the paper and does not remain on the surface; for important documents, however, such as bills of exchange, etc., it is suitable, because, under the influence of acids, even the carbonic acid present in the air, it will in time disappear. The solution of phenolphthalein should be prepared with dilute alcohol.

Fluid extract of ink, according to Dietrich, can be prepared in the following manner: 50 parts of oxidized tannin, 40 parts of dry ferrous sulphate, 3 parts of phenol blue (3 F.), 20 parts of sugar, 1 part of salicylic acid, to 1,000 parts of boiling water. The latter quantity of water is for ink for immediate use. If it is desired to produce a concentrated extract, proportionately less water is required. Oxidized tannin is prepared as follows: 100 parts of tannin are dissolved in 150 parts of water and heated in a flask with 30 parts of powdered bisulphate of potassium, and 10 parts of crude hydrochloric acid (specific gravity 1.16) in a water bath for 10 hours at 175 deg. to 195 deg F. and then reduced to dryness in a porcelain dish. This yields 130 parts of oxidized tannin.

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